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This summarizes studies conducted during 1980 to assess the effects of reductions in phosphorus loading to Saginaw Bay on phytoplankton in the bay and the adjacent waters of Lake Huron. Quantitative estimates of phytoplankton abundance were developed from an array of stations sampled during the ice-free season. Distribution and abundance of major species and multivariate statistical representations of associations were compared to similar data collected during 1974, prior to phosphorus loading reductions. Results show a substantial reduction in the abundance and range of distribution of eutrophication tolerant and potentially nuisance-producing phytoplankton populations in Saginaw Bay and reduced export of such populations to the main Lake Huron system.

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PHYTOPLANKTON SPECIES COMPOSITION, ABUNDANCE AND DISTRIBUTION IN SOUTHERN LAKE HURON, 1980; INCLUDING A COMPARATIVE ANALYSIS WITH CONDITIONS IN 1974 PRIOR TO NUTRIENT LOADING REDUCTIONS

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ABSTRACT

Southern Lake Huron phytoplankton assemblages are characteristic of the meso-oligotrophic associations found in the upper Great Lakes today. However some populations indicative of eutrophic conditions are present and are associated with Saginaw Bay, Thunder Bay and the nearshore zones southward from these areas. Stations in the open waters of southern Lake Huron usually support populations indicative of meso-oligotrophic conditions, however, they show slightly greater average phytoplankton abundances compared to 1974. Several species observed in the offshore waters in 1974 have been significantly reduced in 1980. In general, the offshore waters of Lake Huron show decreases in certain diatom species, and increasing flagellate abundance. However, compared to 1974, many eutrophic forms have been significantly reduced or completely eliminated from the southern basin and outer Saginaw Bay. Substantial decreases in total algal standing crop were observed in Saginaw Bay and are apparently due to reduced nutrient loadings. Aphanizomenon flos-aquae, Anabaena subcylindrica, Oscillatoria retzii and Phacotus lenticularis are representative eutrophic species which were not observed in 1980. Other taxa as Fragilaria capucina, Stephanodiscus binderanus, Actinocyclus normanni fo. subsalsa and Anabaena flos-aquae have been significantly reduced in the study area. In 1974 some of these species were transported from Saginaw Bay and passively dispersed through the southern

basin. Undoubtedly transport of Saginaw Bay assemblages still occurs but does not seem to be as extensive during 1980. This is due to the greatly reduced standing crops of species highly associated with the Saginaw Bay water mass. Nearshore areas in the southern basin and between Alpena and Tawas City, Michigan support high standing crops and appear to be more enriched than previously realized. Thunder Bay also supports high standing crops and some populations that are characteristic of eutrophy.

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INTRODUCTION

Lake Huron is the fifth largest freshwater lake in the world with a surface area of approximately 60,000km^2, volume of 3500km^3 and a mean depth of 53m (Schelske 1975). As it is situated between Ontario, Canada and Michigan, U.S.A., Lake Huron serves as an international boundary and occupies a hydrologically central position in the Laurentian Great Lakes. The outflow of Lake Michigan enters Lake Huron through the Straits of Mackinac and receives input from Lake Superior via the St. Marys River. Lake Huron then discharges through the St. Clair and Detroit River systems to the lower Great Lakes.

Lake Huron can be divided into 6 morphometric regions. It possesses two large embayments, Saginaw Bay and Georgian Bay, of which the latter is the largest. The North Channel lies to the west of Georgian Bay and is the northernmost border of the lake. The main lake body is comprised of the northern, central and southern basins.

Although human population development has not been as extensive as in other areas surrounding the Great Lakes, Lake Huron's present and potential importance to the United States and Canada in terms of industry, municipal usage and recreation is easily perceived.

The phytoplankton assemblages of Lake Huron include populations representative of the entire trophic spectrum found in the Great Lakes today. Vollenweider *et al*. (1974) has summarized the trophic status of Lake Huron, noting that certain localities differ greatly from the remainder of the lake. Georgian Bay, the North Channel and the north and central basins exibit oligotrophic conditions with representative phytoplankton populations and very low standing crops. However, degradation has occurred at nearshore localitites in Georgian Bay (Nicholls _et al_. 1977b) and in the central basin at Alpena, Michigan (Michigan Water Resources Commission 1976, Lowe 1976, Ladewski _et al_. In press).

In contrast to Georgian Bay, Saginaw Bay reached a hypereutrophic state evidenced by large phytoplankton standing crops, high ^{14}C productivity and high concentrations of nutrients and chlorophyll _a_ (Vollenweider _et al_. 1974, Smith _et al_. 1977, Stoermer _et al_. 1982). Freedman (1974) has discussed the long history of eutrophication, taste and odor problems and conservative ion loadings in Saginaw Bay. In terms of phytoplankton species composition and standing crop, Saginaw Bay possesses perhaps the poorest water quality in the Great Lakes rivaled only by the western end of Lake Erie and southern Green Bay. Eutrophy in Saginaw Bay is compounded by other anthropogenic loadings which may produce hidden synergistic effects (Beeton 1965, Fitchko and Hutchinson 1975, Meyers _et al_. 1980).

The southern basin of Lake Huron has long been considered to have high water quality. Recently, study of phytoplankton assemblages have indicated this region may be more closely aligned with mesotrophic conditions (Stoermer and Kreis 1980). The influential factors are not completely known, however, nearshore inputs from both Canada and the U.S. plus the input from Saginaw Bay, may be producing noticeable effects which follow the eutrophication sequence as observed by Beeton and Edmondson (1972).

Accelerated eutrophication has been recognized in the Great Lakes for a number of years and resultant changes in the biota have been documented for all trophic levels (Beeton 1965, Patalas 1972, Smith 1972, Stoermer 1978). Phosphorus has been identified as having the most profound effects in advancing eutrophication (Schindler 1977, Chapra and Robertson 1977). Several studies have shown a high correlation in phosphorus-chlorophyll *a* relationships (Vollenweider 1968, Schindler *et al*. 1973, Schindler *et al*. 1978). The importance of phosphorus in algal production has also been demonstrated for the Great Lakes (Schelske *et al*. 1972, Schelske *et al*. 1974, Schelske *et al*. 1975, Stoermer *et al*. 1978) and the consequences examined (Schelske and Stoermer 1972, Stoermer 1978). Experimental culture studies on Lake Huron phytoplankton showed that phosphorus was the single most important nutrient influencing algal production (Lin and Schelske 1981).

Between 1974 and 1980 the U.S. Environmental Protection Agency has recorded a 50% phosphate loading reduction in Saginaw Bay due to upgraded sewage treatment, a detergent ban and alternative agricultural practices (GLWQB

198o). Chlorophyll *a* concentrations have been continuously monitored in Saginaw Bay and a 50% (ave.) chlorophyll *a* decrease has been observed during the time period (E.P.A. pers. comm.). The present study will compare the effects of phosphorus abatement on southern Lake Huron phytoplankton species composition, abundance and distribution between the 1974 and 1980.

Phytoplankton and chlorophyll *a* concentrations have been studied during lake recovery following phosphorus abatement in the Great Lakes (Vallentyne *et al*. 1970, Nicholls *et al*. 1977a; 1977b; 1980, Dillon *et al*. 1978) and elsewhere (Edmondson 1972, Schindler 1974, Ahlgren 1978). These studies indicate that the response to phosphorus removal is a reduction in algal standing crop accompanied by a species composition change. Usually there is a reduction in nuisance species; however, each system reponds differently and there is no consistent species composition end-point.

Lake Huron algal records date back to the early 1840's and constitute some of the earliest algal studies made in the Great Lakes. A preliminary chronology of Lake Huron algal studies through 1983 is presented in Appendix 1. These studies can be divided into 3 main time groups: 1) pre-1900, 2) 1900-1960 and 3) 1960 to the present. For the most part, studies during the first two periods are few and are of local or peripheral interest. Macroscopic attached algae have been studied through all time periods (Bailey

1847, Klugh 1911; 1913; 1915, Herbst 1969) and more recently by Auer and Canale (1980) and Stevenson and Stoermer (1980a; 1980b). However, studies on Lake Huron phytoplankton have been largely neglected. The U.S. Public Health Service (1961) reported the first quantitative estimates of Lake Huron phytoplankton assemblages. Only during the past decade has more intensive sampling produced consistent phytoplankton data regarding species composition, abundance and distribution (Schelske _et al_. 1974, Lowe 1976, Nicholls _et al_. 1977a, Munawar 1977, Stoermer and Kreis 1980).

Marine algal assemblages have been shown to be characteristic of certain water masses, particularly in regard to thermal regimes, and are useful tracers of ocean circulation and current patterns (Braarud _et al_. 1953, Marshall 1971, Motoda and Minoda 1974). Recently this principle has been applied to discriminating water masses in the Laurentian Great Lakes (Schelske _et al_. 1974, Holland and Claflin 1975, Stoermer _et al_. 1976, Stoermer and Kreis 1980, Kreis _et al_. 1983). In these studies, water mass differentiation resulted from contrasting algal assemblages based on either their habitat preference or trophic association resulting from nutrient loading.

Schelske _et al_. (1974) observed latitudinal differences in Lake Huron phytoplankton species composition and abundance indicating differing degrees of eutrophication. Of particular interest, phytoplankton populations indicative of Saginaw Bay were dispersed, under certain conditions to the open waters of Lake Huron. Stoermer *et al.* (1976) showed that algal assemblages from Lake Michigan, particularly blue-green algae, were transported to northern Lake Huron through the Straits of Mackinac. Vollenweider *et al.* (1974) and Lowe (1976) found that the phytoplankton assemblages of Saginaw Bay were unique and unlike those of the open lake. Similarly, Stoermer and Kreis (1980) observed that the assemblages of Saginaw Bay were distinct and may be used to trace the fate of the Saginaw Bay water mass entering southern Lake Huron.

Several populations had their greatest abundances in Saginaw Bay with decreasing cell numbers moving away from the Bay. Their distributions imply that they are generated in Saginaw Bay and transported toward the open lake. Also scenescent populations may act as seed populations becoming restimulated after transport to other areas of high nutrient input. These factors and the methods which differentiate them will be investigated.

The objectives for this project are to:

1) Determine the phytoplankton species composition, abundance and distribution in southern Lake Huron during 1974 and 1980, then compare and contrast these features in regard to reduced phosphorus loadings.

2) Determine whether or not algal populations associated with Saginaw Bay are being passively transported to southern Lake Huron, are acting as seed populations or are being locally produced independent of Saginaw Bay.

3) Determine the amount, direction and extent of those Saginaw Bay derived phytoplankton which are transported to open Lake Huron for 1974 and 1980 then compare and contrast these features in regard to reduced phosphorus loadings.

The implications of algal transport, particularly in this case, are numerous. Algal assemblages transported from Saginaw Bay may have a significant impact on the production of open lake assemblages. The large phytoplankton biovolume generated in the Bay, sequesters considerable amounts of nutrients bound in particulate form. Additionally, luxury uptake by phytoplankton (as in the formation of polyphosphate bodies) has also been observed in certain Saginaw Bay populations (Stoermer _et_ _al_. 1980). After death and cell decomposition, nutrients are released and become reuseable and may be assimilated by open lake populations.

CONCLUSIONS AND RECOMMENDATIONS

The phytoplankton flora of southern Lake Huron contains populations characteristic of the entire trophic spectrum, ranging from oligotrophic to eutrophic. However phytoplankton assemblages in the offshore waters of southern Lake Huron are those that typically develop under meso-oligotrophic conditions.

Analysis of phytoplankton abundances and species associations indicate that there are 5 major floristic regions in the study area. The regions apparently correspond to various amounts of nutrient loading. Typically, nearshore regions showed highest standing crops and higher abundances of species which characteristically respond to nutrient input.

Saginaw Bay and the nearshore area south of Saginaw Bay in the southern basin, generally showed the highest cell concentrations and species that are most highly associated with eutrophication. Many of the assemblages observed on the southern coastline contain scenescent populations that are transported from Saginaw Bay and are restimulated by local shoreline input. Similarly, the nearshore zone between Alpena and Tawas City showed high phytoplankton standing crops and some eutrophic floristic components. The Canadian nearshore zone in the southern basin generally exhibited moderate cell densities and species which may be found in the offshore waters or are considered eurytopic populations. The Saginaw Bay water mass showed assemblages that were the most impacted by anthropogenic inputs. However phytoplankton assemblages detected in the Michigan nearshore region of the central basin, indicates that this area is more enriched than previously thought and should receive more concern and surveillance activity.

The 2 offshore regions identified in phytoplankton analysis generally show low standing crops and species characteristic of meso-oligotrophic conditions. The region in the western offshore sector, however, showed close affinities to the central basin nearshore zone, possibly indicating affects of nearshore loadings and slight nutrient enrichment from Saginaw Bay.

The outer Saginaw Bay area showed the most significant differences in total cell concentrations as compared to 1974. Although the entire study area showed small reductions in cell concentrations, several individual stations in outer Saginaw Bay experienced order of magnitude decreases. Accompanying standing crop decreases, were reductions or in some cases, total elimination of populations characteristic of eutrophic or hypereutrophic conditions. Some of the species that were eliminated from this area were classic nuisance species. The offshore waters of southern Lake Huron showed slight increases in phytoplankton abundance or remained unchanged compared to 1974 data. However several diatom species found in the open waters in 1974 were observed in very low abundances or were not detected in 1980. Also, generally increasing amounts of phytoflagellates were observed. This observation is may be an indication of continued population succession in the offshore waters. However these trends are difficult to interpret due to the unsatisfactory stat of knowledge of flagellate populations and probable year to year variations due to factors other than nutrient loadings.

Our results indicate that nutrient loading reductions in Saginaw Bay have had a positive effect in reducing phytoplankton abundance and dispersal of potential nuisance populations in the study area. Further monitoring would be necessary to clearly define this trend and account for fluctuations which may result from climatological factors and intrinsic cycles of phytoplankton abundance.

Reduced standing crops were also observed on the Canadian nearshore zone of the southern basin. The high cell concentrations observed in this area in 1974 were partially due to high concentrations of nutrients entrained by the spring thermal bar. This physical regime may not have been as extensively sampled in 1980 as in 1974, resulting in apparently reduced algal cell numbers. The differences observed in the offshore waters of southern Lake Huron are very subtle. However, since only minor increases or no change in cell concentrations were observed, it is possible that remedial actions have at least contributed to the more or less static conditions found between the two sampling years.

During 1974, large populations were observed to be transported from Saginaw Bay to the open lake. These were considered to be an added nutrient burden to the offshore waters. Also concern for the transport of toxic compounds and other anthropogenic substances which are sorbed by phytoplankton was indicated. In 1980, transport of phytoplankton assemblages was not as extensive and transboundary movement was not apparent, due to the lower standing crops observed and to the absence of species which were highly associated with hypereutrophic conditions and Saginaw Bay. The dramatic decrease in algal transport found during this survey is attributable to nutrient reductions. Decreases in algal transport probably have also had a positive effect in preserving the water quality of the open waters of the southern basin. The physical processes of transport are still apparent, but loadings of potentially obnoxious algal populations have been minimized.

MATERIALS AND METHODS

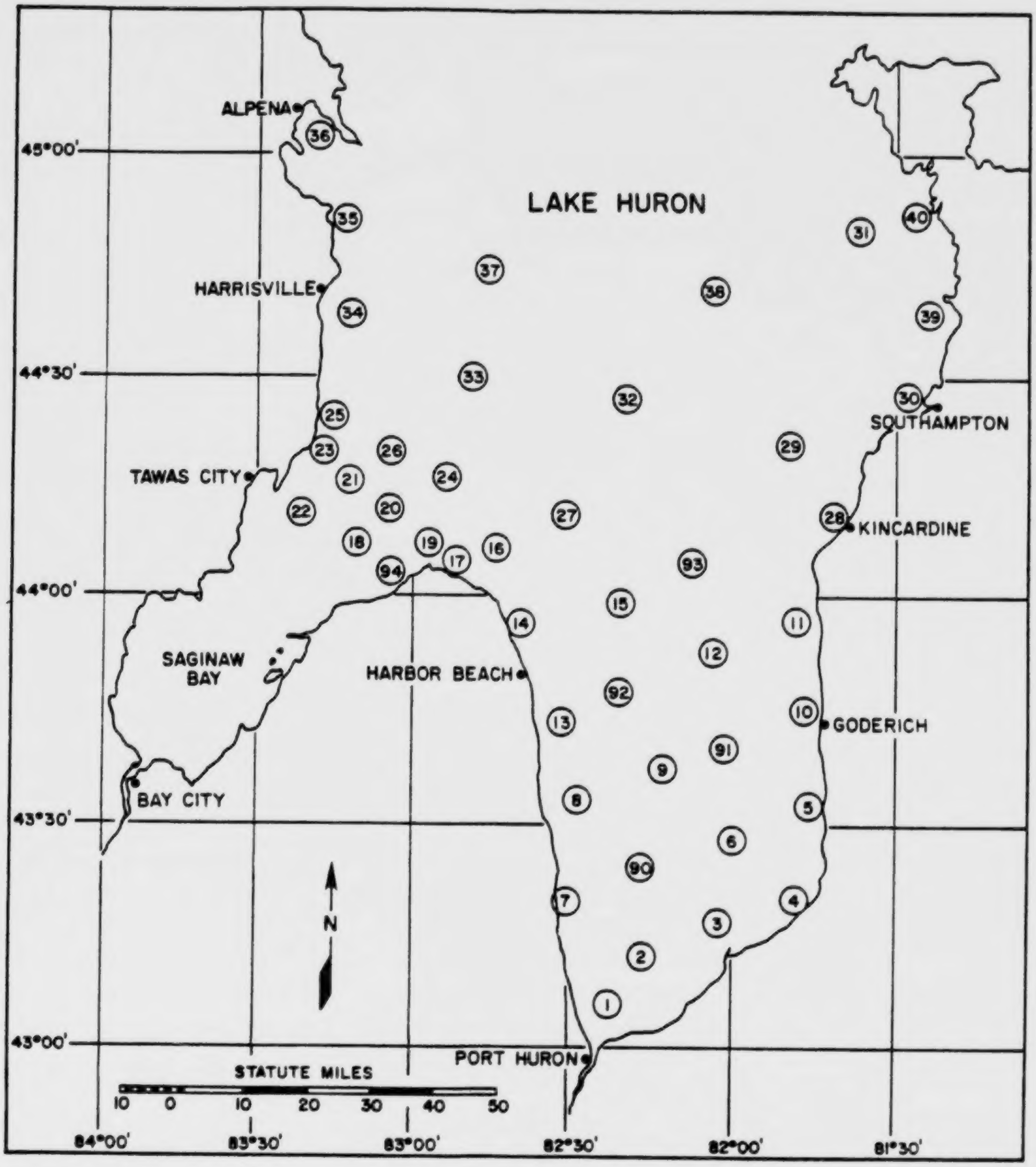
SAMPLING ARRAY. Phytoplankton samples were collected from southern Lake Huron during the ice-free months of 1980. Three cruises were conducted aboard each the CSS LIMNOS and the R/V Roger R. SIMONS. Cruise summaries including cruise dates, duration, vessel used and number of samples collected are presented in Table 1. The research vessels were continuously operated on a 24 hr basis excepting short term layovers due to weather conditions.

The sampling array is presented in Figure 1. Sampling coverage included the southern and central basins of Lake Huron and the outer Saginaw Bay region. Stations were, in general, sampled south to north starting at Port Huron and proceeding northward across the southern basin in a diagonal pattern. Outer Saginaw Bay and the interface region were sampled in a zig-zag pattern from south to north. Sampling in the central basin was comprised of two east-west transects terminating in Thunder Bay at Alpena, Michigan. The typical sampling sequence and 5m phytoplankton sample numbers are presented in Table 2. Additional samples were collected from depths at station 9 (1,10,15 20,25,30,50,57m), station 94 (1,7,12m) and station 32 (1,15,25,70,80m). All stations were sampled for all cruises except for the 2 northernmost transects during the first cruise, due to adverse weather conditions.

In general, the station array covered the southern basin extremely well. A more dense sampling pattern for the

Table 1.
SUMMARY OF SOUTH LAKE HURON CRUISE SEASON, 1980.

Date	Vessel	Sample #	Total Slides
April 9 - 17	R/V SIMONS	1 - 64	64
May 10 -13	R/V SIMONS	65 - 126	62
May 28 - June 2	CSS LIMNOS	127 - 184	68
July 18 - 22	R/V SIMONS	185 - 246	62
September 8 - 12	CSS LIMNOS	247 - 321	74
October 22 - 28	CSS LIMNOS	322 - 377	56


LAKE HURON
ALPENA
HARRISVILLE
TAWAS CITY
SAGINAW BAY
BAY CITY
HARBOR BEACH
PORT HURON
SOUTHAMPTON
KINCARDINE
GODERICH
N
STATUTE MILES
10 0 10 20 30 40 50
45°00'
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43°00'
84°00'
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Figure 1. Sampling Array, Southern Lake Huron, 1980 Sampling Season.

Table 2.
PHYTOPLANKTON 5 METER SAMPLE/SLIDE #'s BY CRUISE

STA #	1	2	3	4	5	6
01	17	65	127	185	247	322
02	18	-	128	186	248	323
03	19	68	129	187	249	324
04	20	69	130	188	250	325
05	21	70	131	189	251	326
06	22	71	132	190	252	327
90	23	72	133	191	253	328
07	24	73	134	192	254	329
08	25	74	135	193	255	330
09	27	76	137	195	257	332
91	34	83	144	205	266	335
10	35	84	145	206	267	336
11	36	85	146	207	268	337
12	37	86	147	208	269	338
92	38	87	148	209	270	339
13	39	88	149	210	271	352
14	40	89	150	211	272	351
15	41	90	151	212	273	353
93	42	91	152	213	274	354
27	43	92	153	215	275	355
16	44,16	93	154	216	276	356
17	45,15	94	155	217	277	350
24	55,13	95	167	219	290	357
19	46,14	96	156	218	278	349
94	53	98	158	221	280	341
18	49,10	101	161	223	284	343
20	57,6	102	160	224	283	348
26	58,5	103	166	225	289	358
21	59,4	104	163	226	286	347
22	47,3	105	162	227	285	344
23	60	106	164	228	287	345
25	61,1	107	165	229	288	346
34	62	126	169	230	319	375
33	-	108	168	231	291	359
32	-	110	172	233	292	361
29	-	114	182	238	311	367
28	-	115	181	214	312	368
30	-	116	180	239	313	369
39	-	117	179	240	314	370
40	-	118	178	241	315	371
31	-	119	177	242	316	372
38	-	120	176	243	317	373
37	-	121	170	244	318	374
35	63	123	183	245	320	376
36	64	125	184	246	321	377

central basin, especially for the open waters, may have been beneficial, however the present design is good. For completeness, particularly for assessing the impact of Saginaw Bay on the open lake, sampling coverage could have been more dense for as well as extended deeper into Saginaw Bay. The Saginaw Bay-Lake Huron interface, however had ample coverage. In general, the nearshore zones around the study area were well represented.

SAMPLE COLLECTION, PREPARATION AND MICROSCOPIC ANALYSIS. Samples were collected from discrete depths by Niskin bottle casts. For the purpose of this study only samples from 5m will be discussed. Whole water subsamples (125 mL) were split from 8-L Niskin bottles, fixed with glutaraldehyde (4% by volume), and refrigerated. The subsamples were stored in the dark for at least 4 hr to assure complete fixation. After gentle sample agitation for phytoplankton resuspension, a 50 mL aliquot was filtered through a .8um, 25-mm AA Millipore filter and dehydrated by an increasing concentration ethanol series. The filter was then embedded in clove oil on a 50- X 75-mm slide and covered with a 43- X 50-mm coverglass. After filter clearing, additional mounting media was added to the slides for replacement due to volatilization. Coverglasses were ringed with parafin to increase slide longevity.

Microscopic identification and enumeration were accomplished using a Leitz Ortholux research microscope fitted with a fluorite immersion objective (N.A. 1.32) rendering a magnification of 1,200X. Quantitative population estimates were calculated from two 10-mm transect counts corrected for volume filtered, effective filtration diameter and microscope field width.

A total of 259 5m samples were analyzed for phytoplankton species composition and abundance. Slides used for population analysis are housed at the Great Lakes Reseach Division, The University of Michigan.

Niskin bottle subsamples were also used for physical parameters, nutrient chemistry and chlorophyll a measurements. A complete account of analytical techniques and physico-chemical data presentation can be found in Moll and Rockwell (In prep.).

DATA MANAGEMENT AND PRESENTATION. Phytoplankton data were computer formated and then reduced through a series of computer programs developed at the Great Lakes Research Division. Similarly, data presentation in the form of abundance plots and graphs are produced through internally developed programs.

Raw data and sample information is read through an internal program producing output in the reduced format presented in Table 3. Each sample is described in terms of absolute and relative abundances of the major algal divisions and individual species. Total phytoplankton abundance, number of species observed, assemblage diversity (H'), assemblage evenness and statistical error associated with quantitative estimates are also calculated.

```
                    SLH South Lake Huron 05 September 1980

              project:   SLH                        survey number:   5
                 year:  1980                           Julian day: 253 ( 9 Sep)
              station:    15                                depth:   5.0 m
             latitude:    44° 00.0'                     longitude:  82° 21.0'
number of cells counted: 1329           volume of water scanned:   0.477 ml

            diversity:      1.853                        evenness:   0.540


                                   number of
         division                   species   cells/ml     SE     CV    % pop.

Cyanophyta (blue-green algae) . .       3      1734.2   188.5   0.11   62.302
Chlorophyta (green algae) . . . .       7       140.3    60.7   0.43    5.041
Bacillariophyta (diatoms) . . . .       4       261.8     6.3   0.02    9.406
Chrysophyta (chrysophytes). . . .       7       345.6   232.5   0.67   12.415
Cryptophyta (cryptomonads). . . .       6       106.8     2.1   0.02    3.837
Pyrrophyta (dinoflagellates). . .       3         8.4     0.0   0.0     0.301
other . . . . . . . . . . . . . .       0         0.0     0.0   ****    0.0
undetermined. . . . . . . . . . .       1       186.4    18.8   0.10    6.697
total                                  31      2783.4   337.2   0.12  100.000


         species name                          cells/ml     SE     CV    % pop.

Anacystis incerta . . . . . . . . . . . . . .   1397.0    77.5   0.06   50.188
Chrysosphaerella longispina . . . . . . . . .    291.1   261.8   0.90   10.459
Gomphosphaeria lacustris. . . . . . . . . . .    259.7   259.7   1.00    9.330
Cyclotella comensis . . . . . . . . . . . . .    245.0     6.3   0.03    8.804
Undetermined flagellate spp. . . . . . . . .     186.4    18.8   0.10    6.697
Anacystis thermalis . . . . . . . . . . . . .     77.5     6.3   0.08    2.784
Botryococcus braunii. . . . . . . . . . . . .     73.3    73.3   1.00    2.634
Rhodomonas minuta var. nannoplanctica . . . .     56.5     2.1   0.04    2.032
Dinobryon divergens . . . . . . . . . . . . .     37.7    29.3   0.78    1.354
Gloeocystis planctonica . . . . . . . . . . .     27.2    27.2   1.00    0.978
Rhodomonas minuta . . . . . . . . . . . . . .     20.9     4.2   0.20    0.752
Chroomonas spp. . . . . . . . . . . . . . . .     14.7    10.5   0.71    0.527
Oocystis spp. . . . . . . . . . . . . . . . .     14.7     2.1   0.14    0.527
Cryptomonas spp.. . . . . . . . . . . . . . .      8.4     4.2   0.50    0.301
Cyclotella pseudostelligera . . . . . . . . .      8.4     8.4   1.00    0.301
Eutetramorus spp. . . . . . . . . . . . . . .      8.4     8.4   1.00    0.301
Lagerheimia ciliata . . . . . . . . . . . . .      8.4     8.4   1.00    0.301
Monochrysis aphanaster. . . . . . . . . . . .      6.3     2.1   0.33    0.226
Cosmarium botrytis. . . . . . . . . . . . . .      4.2     4.2   1.00    0.150
Cryptomonas ovata . . . . . . . . . . . . . .      4.2     0.0   0.0     0.150
Cyclotella comta. . . . . . . . . . . . . . .      4.2     4.2   1.00    0.150
Cyclotella michiganiana . . . . . . . . . . .      4.2     4.2   1.00    0.150
Undetermined green individual . . . . . . . .      4.2     4.2   1.00    0.150
Mallomonas pseudocoronata . . . . . . . . . .      4.2     0.0   0.0     0.150
Spirodinium pusillum var. minor?. . . . . . .      4.2     4.2   1.00    0.150
Ceratium hirundinella . . . . . . . . . . . .      2.1     2.1   1.00    0.075
Chrysococcus dokidophorus . . . . . . . . . .      2.1     2.1   1.00    0.075
Gymnodinium spp.. . . . . . . . . . . . . . .      2.1     2.1   1.00    0.075
Chroomonas nordsetdii . . . . . . . . . . . .      2.1     2.1   1.00    0.075
Chrysophycean flagellate spp. . . . . . . . .      2.1     2.1   1.00    0.075
Ochromonas spp. . . . . . . . . . . . . . . .      2.1     2.1   1.00    0.075
```

Table 3. Computer Reduced Phytoplankton Format.

A descriptive summary for the year and for each of the 6 individual cruises are also provided. The summaries include a floristic list of taxa encountered, the number of samples in which the taxon appears and average and maximum absolute and relative abundances for each the year and cruise.

Seasonal distribution and abundance of algal divisions and selected species are illustrated by computer generated plots. Computer generated line graphs for divisions and species are also presented for the inspection of seasonal trends. These data are also presented in tabular form.

We have also summarized the abundance and distribution of both total phytoplankton and the major algal divisions according to the lake segmentation scheme developed by the International Joint Commission (1977). The IJC segmentation scheme is presented in Figure 2. Since Saginaw Bay presents a unique species composition and usually maintains high algal standing crops, we have added an additional segment, designated as 7a on Figure 2. These stations generally retain characteristics more closely aligned with inner Saginaw Bay and should be examined separately from the remainder of the southern basin. The IJC segmentation scheme is overlain on the 1980 sampling array in Figure 3 and the station numbers are grouped by segment in Table 4.

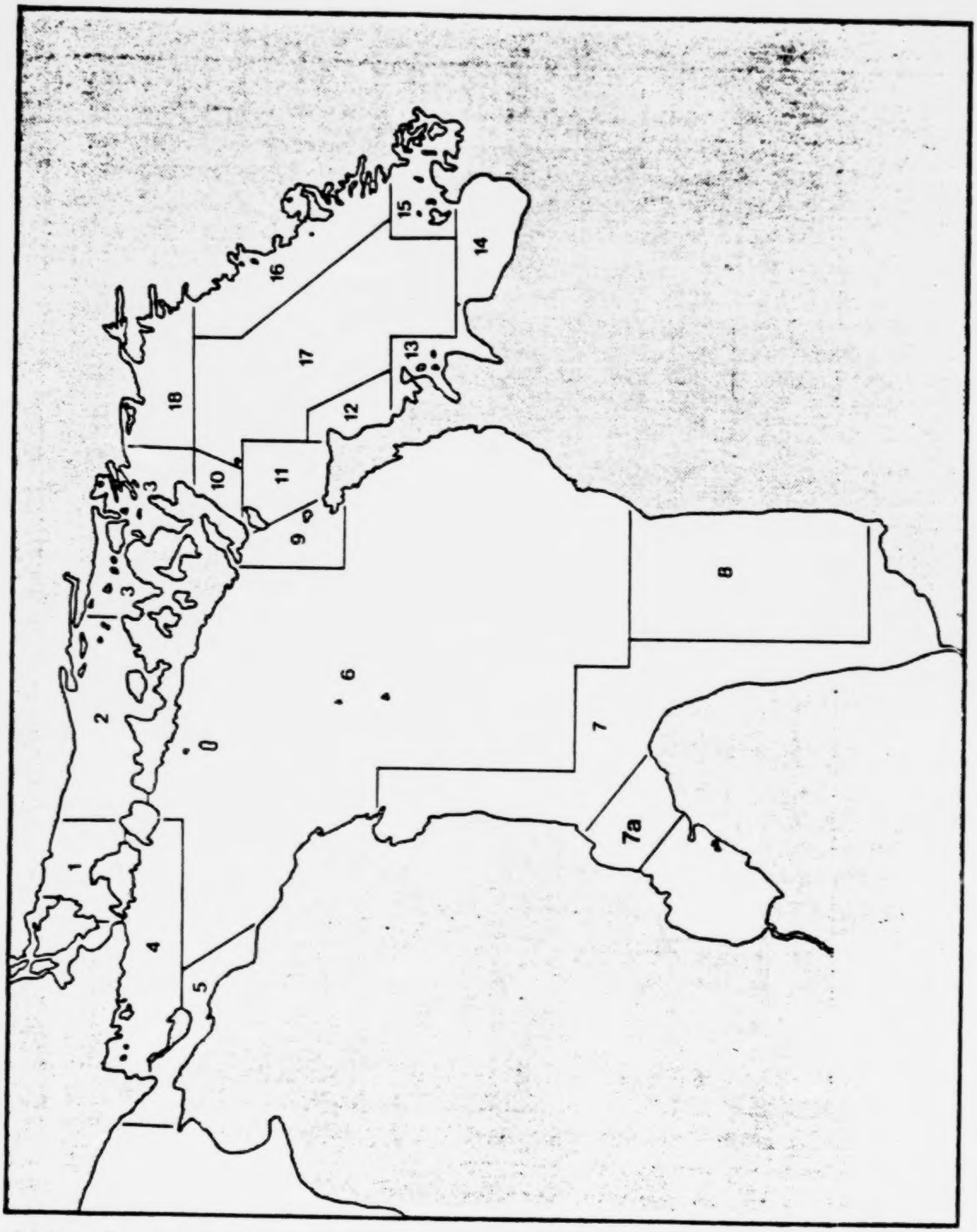
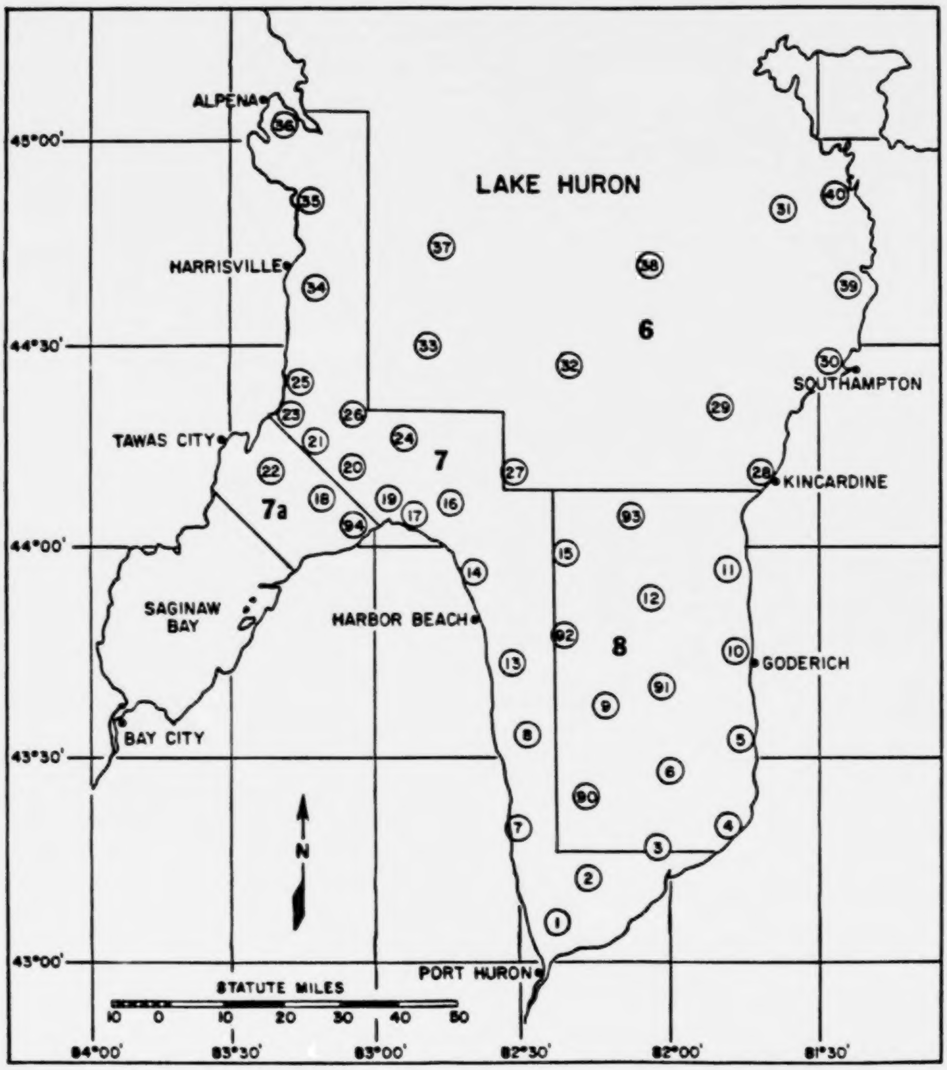

1
2
3
3
3
4
5
0
6
7
7a
8
9
10
11
12
13
14
15
16
17
18

Figure 2. Segmentation Scheme Developed by the International Joint Comm.


LAKE HURON
ALPENA
HARRISVILLE
TAWAS CITY
SAGINAW BAY
BAY CITY
HARBOR BEACH
PORT HURON
SOUTHAMPTON
KINCARDINE
GODERICH
6
7
7a
8
45°00'
44°30'
44°00'
43°30'
43°00'
84°00'
83°30'
83°00'
82°30'
82°00'
81°30'
N
STATUTE MILES
10 0 10 20 30 40 50
1
2
3
4
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6
7
8
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90
91
92
93
94

Figure 3. Southern Lake Huron Sampling Array in the IJC Segmentation Scheme.

Table 4.
1980 Southern Lake Huron Sampling Stations Grouped According to the IJC Segmentation Scheme

	7a	7	8	6
	18	1	3	27
	22	2	4	28
	94	7	5	29
		8	6	30
		13	9	31
		14	10	32
		16	11	33
		17	12	37
		19	15	38
		20	90	39
		21	91	40
		23	92	
		24	93	
		25		
		26		
		34		
		35		
		36		
n=	3	18	13	11

RESULTS

Survey-wide Averages

The overall abundance of phytoplankton at all stations sampled through all cruises is presented in table 5. The total average phytoplankton abundance for the study area, is moderate showing a modest range of total algal concentrations within one order of magnitude. Of the major physiological groups observed, diatoms were the most abundant in southern Lake Huron comprising 35% of the assemblage. Blue-green algae and an undetermined category were the two next abundant groups. The undetermined category is primarily composed of microflagellates which cannot be satisfactorily determined using light microscopic techniques and subsequently cannot be assigned to a divisional group. Many of the flagellate forms are not well known for or have only recently been reported from the Great Lakes and may be aligned with the Haptophyta, Chloromonadophyta, Chrysophyta and Prasinophyta (Munawar and Munawar 1975, Stoermer and Sicko-Goad 1977, Nicholls _et al_. 1977). Chrysophytes and cryptomonads, both flagellate groups, were common in the study area. Green algae, on average, were a minor component of planktonic assemblages. Dinoflagellates and euglenoids were a very small fraction of the southern Lake Huron algal flora. Flagellate forms can be found in all the major algal divisions, excepting the blue-green algae and diatoms. When all phytoflagellates are considered collectively, they constitute a substantial portion of planktonic assemblages observed.

Seasonal Averages of Total Phytoplankton and the Major Algal groups

Seasonal trends of total phytoplankton are presented in table 6 and figure 4. Total algal abundance for southern Lake Huron exhibited a bimodal pattern in 1980 (fig. 4). Highest total standing crop was observed in April with slightly less abundance in September and October. A summer minimum was observed in July where the lowest standing crop values for the sampling period were recorded in July.

Mean seasonal values for the major algal divisions are given in table 6 and figures 5 and 6. Diatoms showed fairly consistent values through all seasons with the highest abundance recorded in October and lowest in September. Blue-green algae showed greatest abundance and dominated in September and October. Largest mean values for green algae were observed in August however most values were uniform through the sampling season. Chrysophytes reached their highest abundance during the spring in April and May and were observed in lowest abundance in July. Cryptomonads showed seasonal consistency through the sampling period but were most abundant in May with lowest values recorded for July. Dinoflagellate standing crop was very low with greatest abundance in June. Euglenoids were virtually absent from the study area. The undetermined category (primarily microflagellates) were in greatest abundance in

Table 5. Summary of southern Lake Huron Phytoplankton for all cruises (1-6) at 5 meters, 1980.

Ave. cells/mL	1881.2
Range (cells/mL)	222.0 - 6272.7
Standard deviation	997.3
Mean diversity	2.389

	*Ave. Relative Abundance (%)	Ave. Absolute Abundance (cells/mL)
Blue-greens	18.85	413.63
Greens	5.41	96.67
Diatoms	35.52	649.02
Chrysophytes	11.12	200.15
Cryptomonads	8.78	141.75
Dinoflagellates	.33	5.36
Euglenoids	<.01	.01
Undetermined	19.94	373.41

*Average relative abundance, as presented here, is calculated by dividing the sum of assemblage percentages by the total number of samples. Relative abundance can also be calculated from the values presented by dividing the average absolute abundance by the average total abundance. Differences between the two calculation methods are negligible in this data set.

April with decreasing values through the remainder of the year.

Segment Averages

In order to inspect regional differences in total and divisional algal abundance, mean values are presented according to the IJC segmentation scheme as previously discussed.

Mean phytoplankton abundance by segment for each cruise is given in table 7. Segment 7a exibited the highest average abundance for the sampling period and generally the highest individual cruise values. Segment 7 had slightly lower, but similar abundance values, in comparison to segment 7a. Segments 6 and 8 showed considerably lower mean abundances compared to the other two segments. Segment 6 usually showed the lowest cruise values for the study area.

Mean absolute and relative abundances of algal divisions are given in tables 8 and 9, respectively. Highest mean absolute abundances for green algae, diatoms and chrysophytes were recorded for segment 7a. Greatest absolute abundance of blue-greens and the undetermined category were recorded in segment 7. Diatoms were the most abundant division in all segments usually by a substantial amount. Highest mean absolute abundances of cryptomonads and dinoflagellates were recorded for segment 8 but abundances for both groups were consistent throughout all segments.

Table 6.
Seasonal means of southern Lake Huron total phytoplankton and major algal groups (cells/mL) for cruises 1-6 at 5 meters, 1980.

	CRUISE					
GROUP	1	2	3	4	5	6
Total	2400.2	1905.7	1639.7	1100.2	2190.4	2166.7
Blue-greens	177.5	150.6	202.6	21.7	994.2	876.9
Greens	72.4	112.0	88.5	73.4	123.6	105.1
Diatoms	696.4	596.0	651.9	621.9	585.1	752.3
Chrysophytes	363.9	336.3	168.1	52.0	159.2	160.9
Cryptomonads	151.2	266.3	164.2	83.3	89.5	101.0
Euglenoids	0.0	0.0	0.0	0.0	0.1	0.0
Dinoflagellates	3.0	5.2	8.9	5.3	7.0	2.2
Undetermined	930.4	437.2	355.4	242.6	231.8	168.3

Figure 4.
MEAN SLH PHYTOPLANKTON ABUNDANCE AT 5M FOR CRUISES 1-6

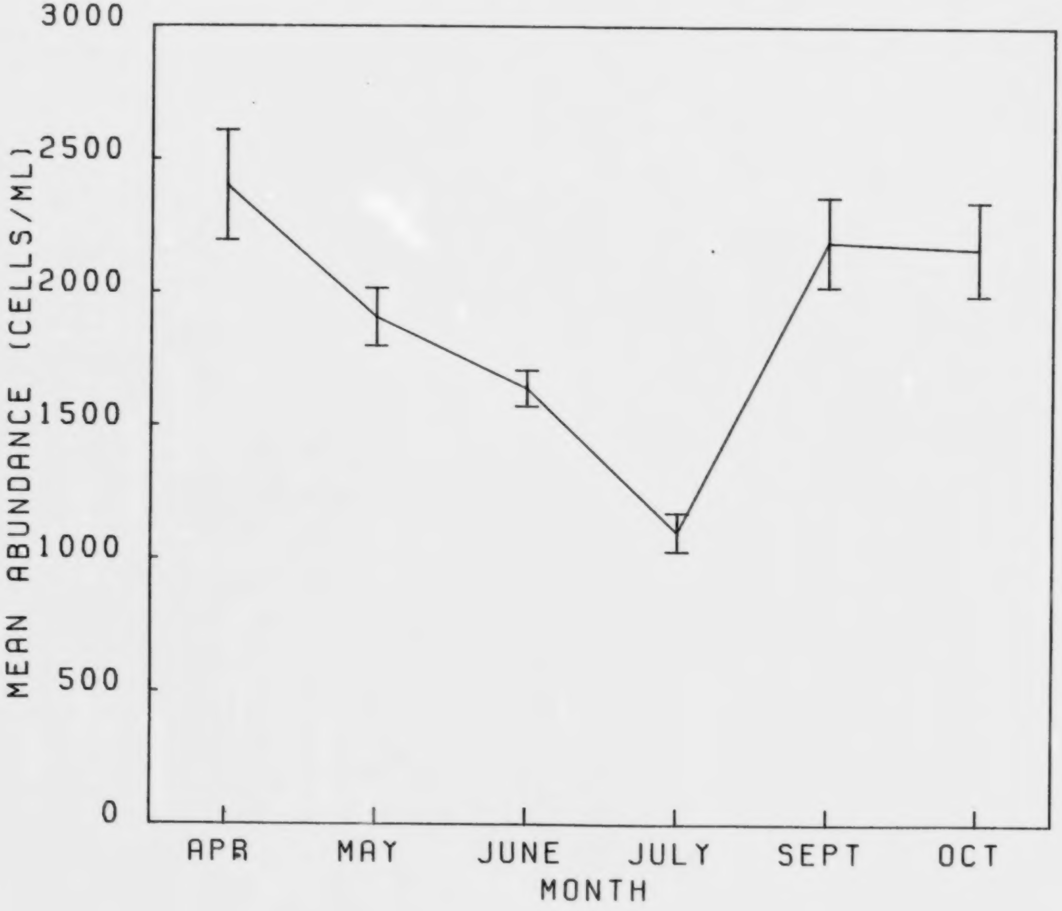


Figure 5.
MEAN ABUNDANCE OF BLUE-GREENS, GREENS AND DIATOMS AT 5M

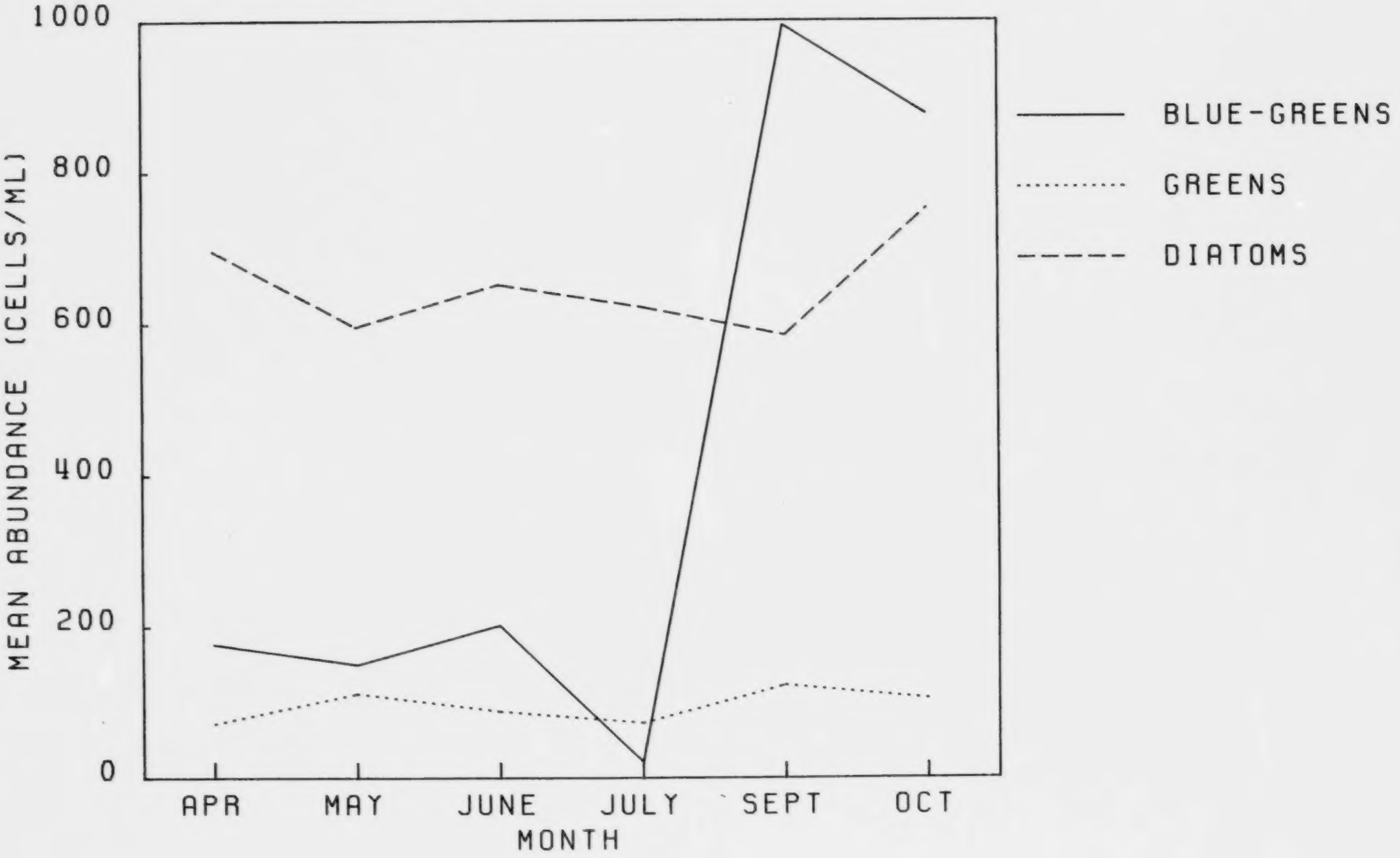


Figure 6.

MEAN ABUNDANCE OF CHRYSOPHYTES, CRYPTOMONADS AND UNDETERMINED MICROFLAGELLATES AT 5M

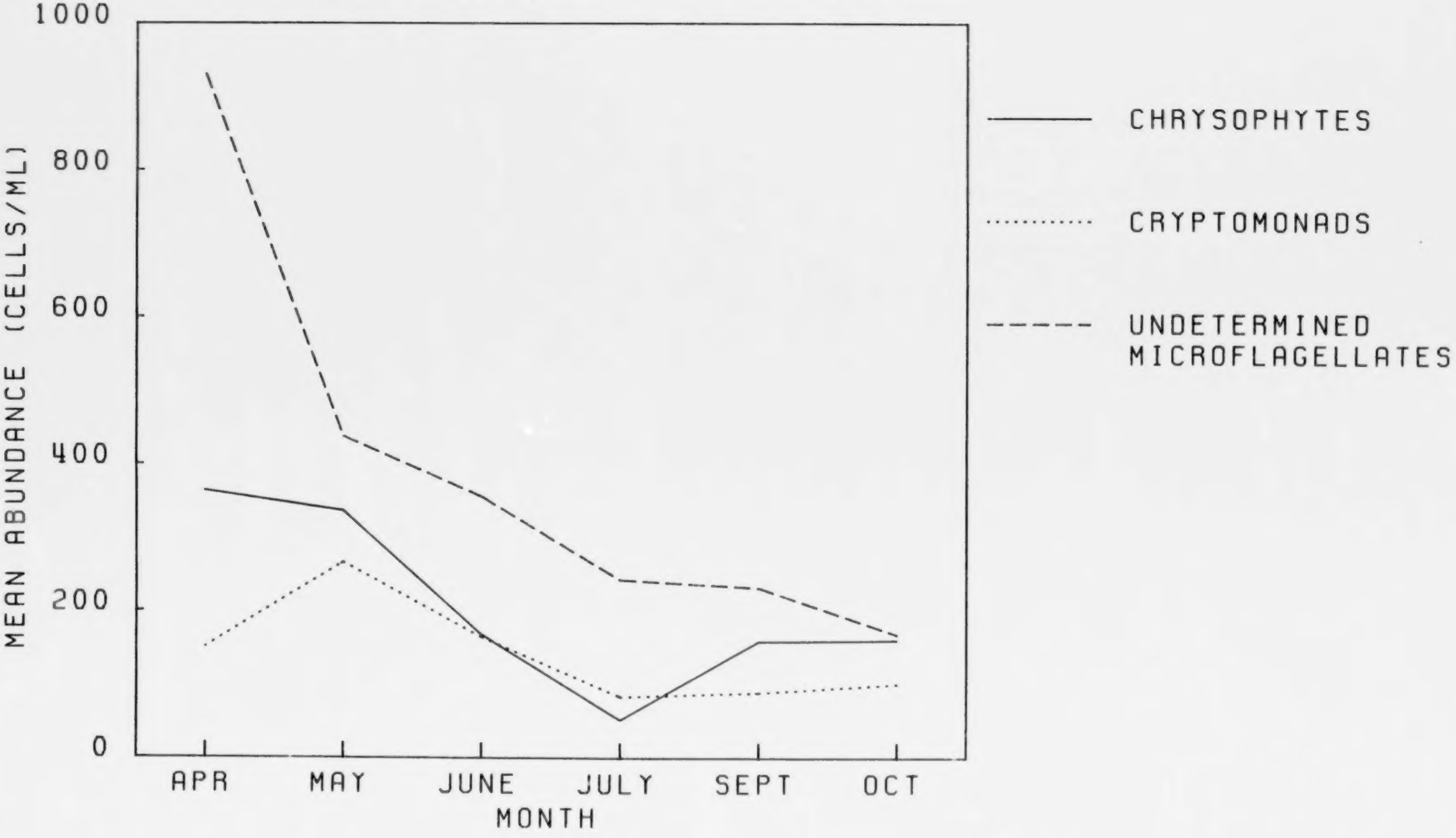


Table 7. Mean Phytoplankton Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

SEGMENT	CRUISE						Yearly Mean
	1	2	3	4	5	6	
6	1309.0	1393.2	1565.1	921.1	1627.7	1259.9	1352.6
7a	3000.6	2594.3	1891.2	1237.8	2801.6	3619.1	2524.1
7	3024.7	2003.0	1726.9	1409.5	2785.4	2830.9	2299.5
8	1481.1	2053.2	1524.1	791.5	1701.8	1679.2	1538.5

Table 8. Mean Absolute Abundance (cells/mL) of Algal Divisions in southern Lake Huron by segment for all cruises (1-6) at 5 meters, 1980.

	GROUP						
SEGMENT	BLUE-GREENS	GREENS	DIATOMS	CHRYSOPHYTES	CRYPTOMONADS	DINOFLAGELLATES	UNDETERMINED
6	331.06	80.41	398.61	154.54	141.18	4.00	242.80
7a	453.55	153.94	1139.70	238.99	131.48	5.70	400.73
7	503.95	102.86	805.42	223.32	130.48	5.70	526.65
8	339.80	86.65	501.10	192.17	160.01	5.80	250.68

Table 9. Mean Relative Abundance (%) of Algal Divisions in southern Lake Huron by segment for all cruises (1-6) at 5 meters, 1980.

	GROUP						
SEGMENT	BLUE-GREENS	GREENS	DIATOMS	CHRYSOPHYTES	CRYPTOMONADS	DINOFLAGELLATES	UNDETERMINED
6	24.48	5.95	29.47	11.43	10.44	.30	17.95
7a	17.97	6.10	45.15	9.47	5.21	.23	15.77
7	21.95	4.47	35.03	9.71	5.67	.25	22.90
8	22.09	5.63	32.57	12.49	10.40	.38	16.29

Relative abundances of green algae and diatoms were highest in segment 7a. Chrysophyte relative abundance however, was lowest in segment 7a and highest in segment 8. Greatest relative abundances of blue-greens and cryptomonads were found in segment 6. Highest relative abundance of the undetermined category was noted in segment 7.

The seasonal trends of total phytoplankton in each segment are shown in figure 7. All four segments show bimodal patterns in total abundance. Highest abundances were recorded in the spring or fall. Segment 6 had the lowest mean seasonal abundance and is marked by the least amount of changes during the season. Cell numbers gradually increased through June and then markedly decreased in July. Abundance was highest for the year in September with decreasing values in October. Segment 8 had slightly greater abundance than segment 6. Mean values increased from April to May, reaching this segments highest mean abundance for the year. Values decreased through June to a summer minimum in July. Mean abundance rose in September with a similar mean value for October. Segment 7 generally had higher mean values than either segment 6 or 8. Highest mean abundance for the year was seen in April. Consecutively less abundance was seen through May, June and then to the summer minimum in July. Much higher values were observed for September and October. Segment 7a had the highest average standing crop of all segments. Its seasonal trend resembled segment 7. High mean values were seen in

April with decreasing values to the lowest mean in July. Large fall values were seen in September attaining the highest mean abundance of this segment in October.

Seasonal trends of the major physiological groups are presented in figure 8. Segment 6 showed reasonably stable abundances through the sampling season. Total flagellates were highest followed by diatoms until September and October when blue-greens dominated. In segment 8 total flagellates were the most abundant in April and May. Diatoms and flagellates were both abundant in June with diatoms dominating in July. Blue-greens were in greatest concentrations in September and October. For segment 7, very large abundances of total flagellates were observed in April and May. Total flagellates were slightly more abundant than diatoms in June with diatoms increasing to dominate in July. Blue-green algae rose to dominate in September and co-dominated with diatoms in October. For segment 7a total flagellates were highest in April and May with diatoms dominating for the remainder of the season. Blue-greens were subdominant in September and October.

Mean assemblage diversities by segment are presented in table 10. Highest yearly averages were seen in segments 6 and 8, however, the mean values for all segments are fairly similar. Large fluctuations in diversity were seen in all segments with highs generally recorded for the spring and lows in the summer.

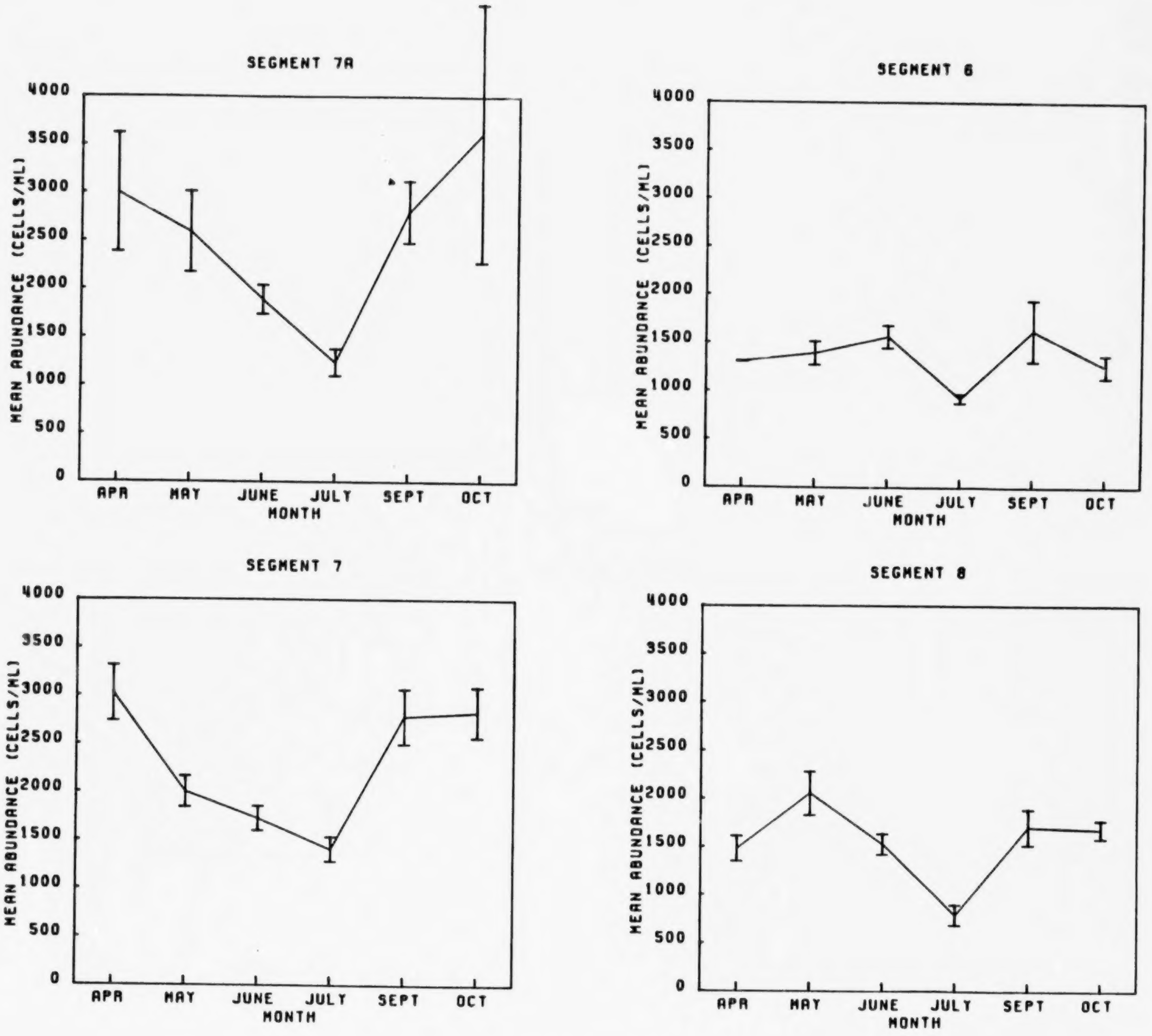


Figure 7. Seasonal trends of total phytoplankton by segment. Error bars = ± Standard error.

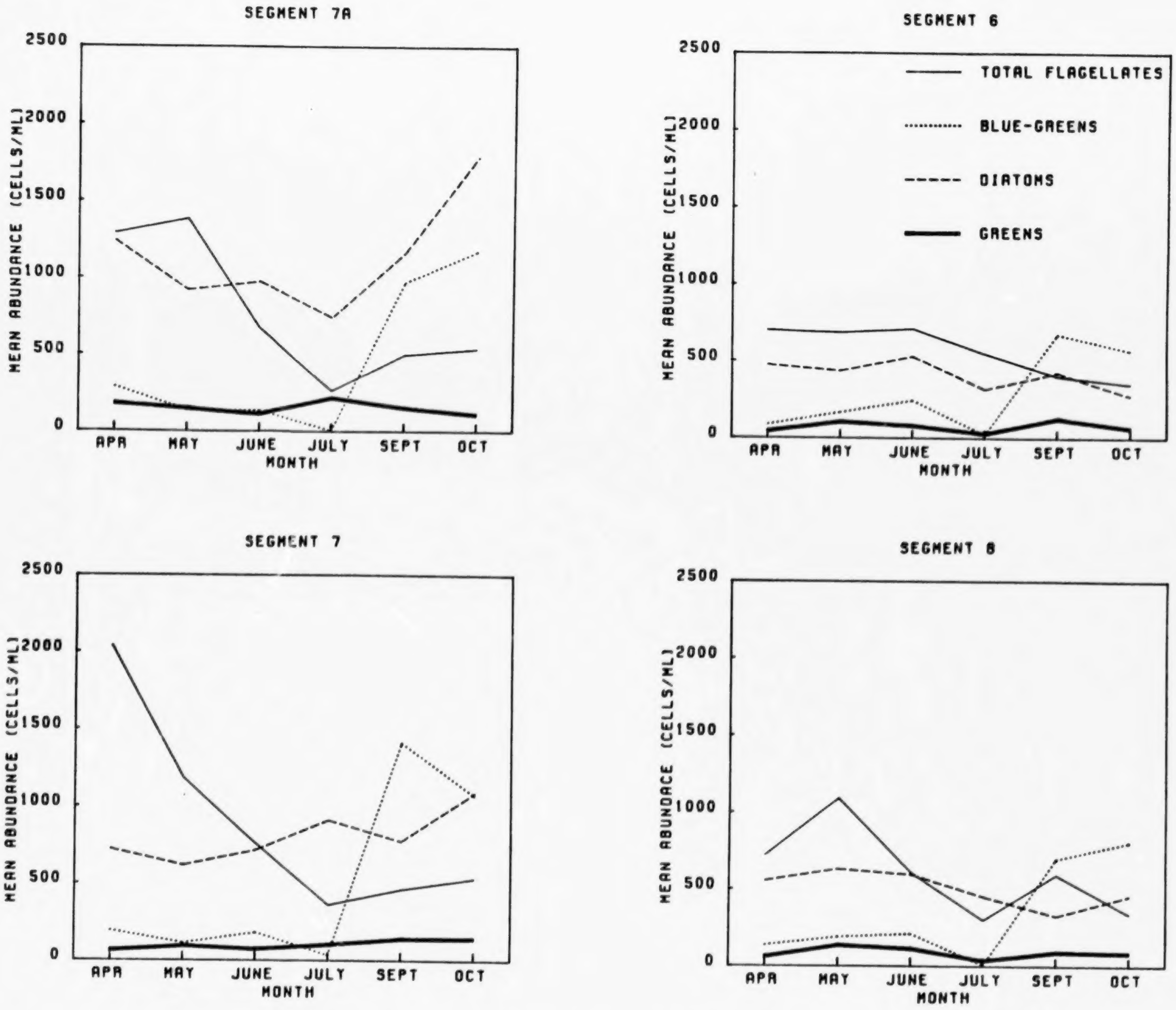


Figure 8. Seasonal trends of the major algal groups by segment.

Table 10. Mean Assemblage Diversity in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE						
SEGMENT	1	2	3	4	5	6	Yearly Mean
6	2.726	2.896	2.792	1.997	2.188	2.444	2.468
7a	3.041	2.719	2.752	1.720	2.099	2.078	2.401
7	2.458	2.641	2.652	1.770	1.963	2.399	2.311
8	2.901	2.829	2.842	1.691	2.088	2.267	2.436

Mean absolute abundances of the major algal groups by segment and cruise are given in tables 11-17. For comparative purposes, mean relative abundances for these groups are presented in tables 18-24 by segment and cruise.

The Phytoplankton Flora of Southern Lake Huron

A summary of the taxa encountered in southern Lake Huron during this study are presented in Appendix 2. Taxa are arranged by divisional group then alphabetically by genus and species. Also given are the average absolute and relative abundance, and the maximum absolute and relative abundances. Appendix 3 presents summaries of the divisions and taxa by cruise. Finally Appendix 4 gives the raw data for each station by cruise in the reduced format discussed previously.

In a number of cases complete taxonomic identification could not be accomplished. These entities were identified to the lowest taxonomic level possible and assigned a number. Identification of these entities could not be accomplished because of poor microscopic views, the lack of critical morphological structures for taxonomic placement or the occurrence of only a few specimens which possess a great deal of variability.

Regional and Seasonal Trends in Total Cell Densities

Highest mean standing crop values for the sampling season were recorded for April. During this month (fig. 9A)

Table 11. Mean Diatom Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	475.43	436.21	528.74	320.25	424.97	275.89
7a	1241.30	922.93	974.59	744.21	1166.60	1788.60
7	720.12	616.12	715.82	910.71	773.30	1085.90
8	554.85	629.61	593.20	449.01	325.76	454.16

Table 12. Mean Abundance (cells/mL) of Green Algae in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	43.98	104.72	80.16	29.51	126.04	64.93
7a	179.42	148.70	111.30	218.52	154.99	111.70
7	64.46	92.65	72.72	102.86	140.67	143.23
8	60.90	134.85	112.29	36.41	90.54	84.90

Table 13. Mean Blue-green Algal Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	87.97	166.98	246.57	23.04	674.01	566.82
7a	288.30	138.93	134.04	7.68	975.29	1177.00
7	193.73	112.48	181.75	34.21	1409.80	1070.00
8	136.30	189.30	209.92	6.44	694.21	802.64

Table 14. Mean Chrysophyte abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	265.99	264.46	185.07	71.78	99.96	141.28
7a	365.82	497.07	108.91	52.36	166.85	242.95
7	396.19	397.20	164.76	59.69	127.53	204.20
8	326.24	280.33	172.06	24.49	251.33	98.60

Table 15. Mean Cryptomonad Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	117.29	181.83	196.30	121.67	106.62	101.67
7a	148.70	321.84	140.32	31.42	59.34	87.27
7	154.64	240.49	148.82	57.36	81.91	105.77
8	149.51	358.62	163.68	98.60	92.48	97.15

Table 16. Mean Dinoflagellate Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	2.09	2.86	9.33	2.67	4.19	1.14
7a	6.28	4.19	9.08	5.59	7.68	1.40
7	2.44	5.79	8.73	6.40	8.26	2.56
8	3.06	6.77	8.86	5.80	7.57	2.74

Table 17. Mean Total Flagellate Abundance (cells/mL) in southern Lake Huron by segment for cruises 1-6 at 5 meters in 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	701.62	685.25	709.62	548.35	402.69	352.24
7a	1291.50	1383.70	672.30	267.38	504.75	541.75
7	2039.80	1181.70	756.66	361.75	461.70	531.74
8	723.21	1092.5	607.86	299.66	591.26	337.52

Table 18. Mean Relative Abundance (%) of Diatoms in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	20.32	19.98	11.83	34.77	26.11	21.90
7a	41.37	35.58	51.53	60.12	41.64	49.42
7	23.81	30.76	41.45	64.61	27.76	38.36
8	37.46	30.67	38.92	56.73	19.14	27.05

Table 19. Mean Relative Abundance (%) of Green Algae in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	3.36	7.52	5.12	3.20	7.74	5.15
7a	5.98	5.73	5.83	17.65	5.53	3.09
7	2.13	4.63	4.21	7.30	5.05	5.06
8	4.11	6.57	7.37	4.60	5.32	5.06

Table 20. Mean Relative Abundance (%) of Blue-green Algae in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	6.72	11.99	15.75	2.50	41.41	44.99
7a	9.61	5.36	7.09	0.62	34.81	32.52
7	6.41	5.62	10.52	2.43	50.61	37.80
8	9.20	9.22	13.77	0.81	40.80	47.80

Table 21. Mean Relative Abundance (%) of Chrysophytes in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	20.32	18.98	11.83	7.79	6.14	11.21
7a	12.19	19.16	5.76	4.23	5.96	6.71
7	13.10	19.83	9.54	4.24	4.58	7.21
8	22.03	13.65	11.24	3.09	14.77	5.87

Table 22. Mean Relative Abundance (%) of Cryptomonads in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	8.96	13.05	12.54	13.21	6.55	8.07
7a	4.96	12.41	7.42	2.54	2.12	2.41
7	5.11	12.01	8.62	4.07	2.94	3.74
8	10.10	17.47	10.74	12.46	5.43	5.79

Table 23. Mean Relative Abundance (%) of Dinoflagellates in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	.16	.21	.60	.29	.26	.09
7a	.21	.16	.48	.45	.27	.04
7	.08	.29	.51	.45	.29	.09
8	.21	.33	.58	.73	.45	.16

Table 24. Mean Relative Abundance (%) of Total Flagellates in southern Lake Huron by segment for cruises 1-6 at 5 meters, 1980.

	CRUISE					
SEGMENT	1	2	3	4	5	6
6	53.60	49.19	45.34	59.53	24.74	27.96
7a	43.04	53.38	35.55	21.60	18.02	14.97
7	67.44	59.00	43.82	25.67	16.58	18.78
8	48.83	53.21	39.88	37.86	34.74	20.10

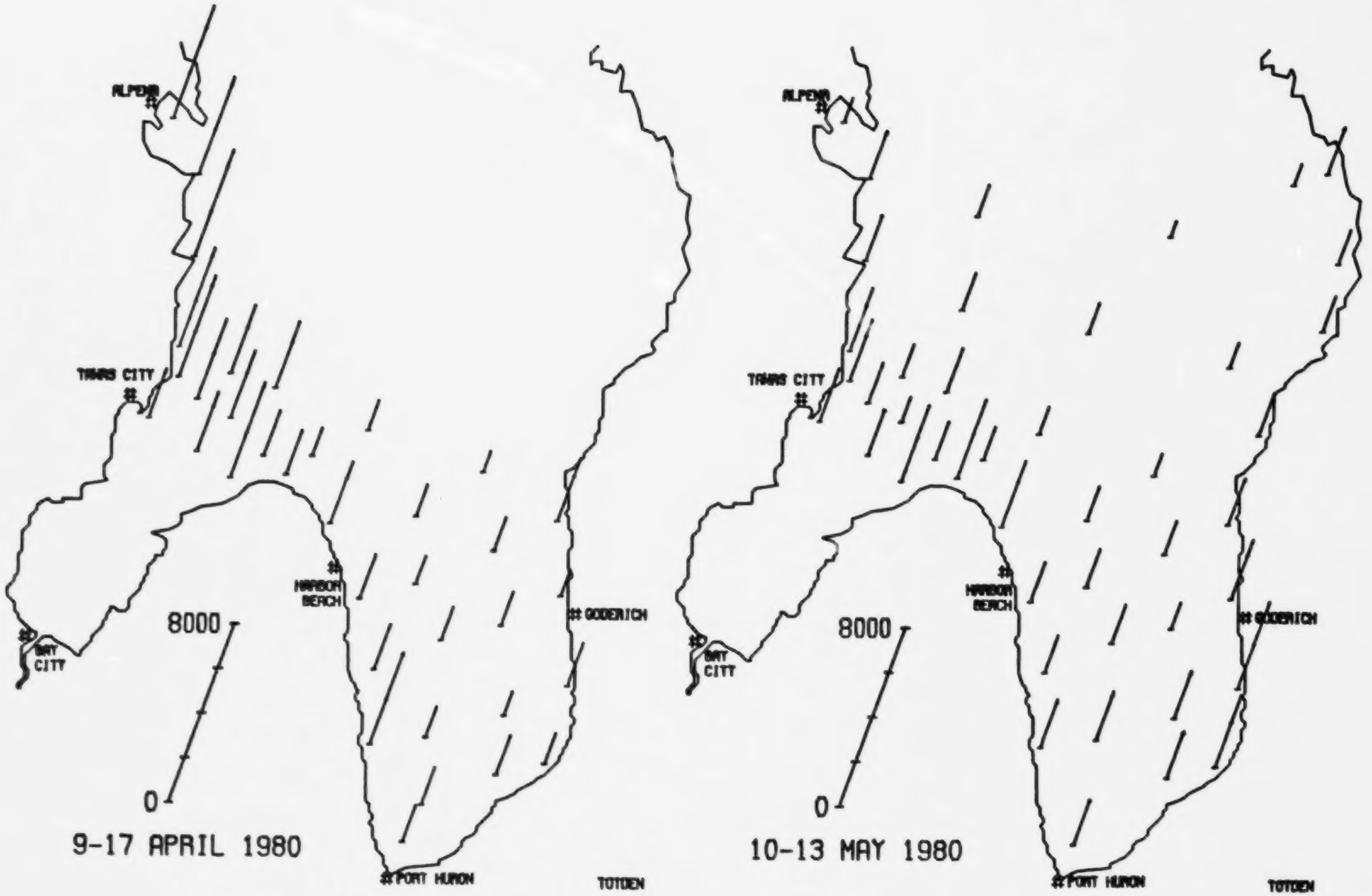
greatest cell numbers were observed in the nearshore zone between Alpena and Tawas City. High abundances were also obseved in outer Saginaw Bay and north of the Saginaw Bay interface. Moderate abundances were generally recorded for the southern basin. In May (fig. 9B) highest abundance was observed in the nearshore zones around the study area and in outer Saginaw Bay. Moderate abundances were observed in the offshore waters of the southern basin and comparatively less in the central basin. Uniform abundances were observed in June (fig. 9C). The greatest cell numbers were recorded in Thunder Bay at Alpena and slightly elevated abundances were found in the Canadian nearshore zone. During July (fig. 9D) cell numbers decreased with highest abundance in the Saginaw Bay interface and southward. Low abundances were observed in both the central and southern basins. In September (fig. 9E) abundance increased over July with highest cell densities occuring in the littoral zone between Alpena and Tawas City. Some high values were also observed adjacent to Saginaw Bay. Moderate abundances were seen in t he southern basin with comparatively less abundance in the north-east sector of the central basin. Abundance in October was similar to the previous sampling period (fig. 9F). Highest standing crops were observed in outer Saginaw Bay and adjacent water and the nearshore zone southward. High abundances were again recorded in the nearshore area between Alpena and Tawas City. Moderate abundances were observed in the southern offshore zone with lesser cell densities observed in the mid-central basin and along the entire Canadian shoreline.

Regional and Seasonal Trends of the Major Algal Groups and Selected Taxa

BACILLARIOPHYTA - DIATOMS

Diatoms comprise a large portion of algal assemblages in the Great Lakes. During this study they accounted for 35% of the assemblages in southern Lake Huron. They have been studied extensively in the Great Lakes due to their numerical importance in assemblages and for use as indicators of trophic status. Diatoms collectively show a wide range of tolerance over the entire trophic range found in the Great Lakes, however, individual species show apparent preferences to particular environmental conditions.

In April (fig. 10A) diatom abundance was greatest at a station in the south-east corner of Saginaw Bay. High values were also seen in the nearshore zone between Saginaw Bay and Port Huron. Relatively uniform cell densities were seen over the remainder of the study area sampled. Highest abundances in May (fig. 10B) were again observed in nearshore zones, possibly in response to spring thermal bar conditions. Greatest abundance was seen in outer Saginaw Bay and around the thumb area. High values were also observed nearshore south of Goderich and south of Thunder Bay. The offshore waters of the south and central basins showed relatively low, uniform abundances. During June (fig. 10C) moderate, uniform abundances were seen over the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BAY CITY
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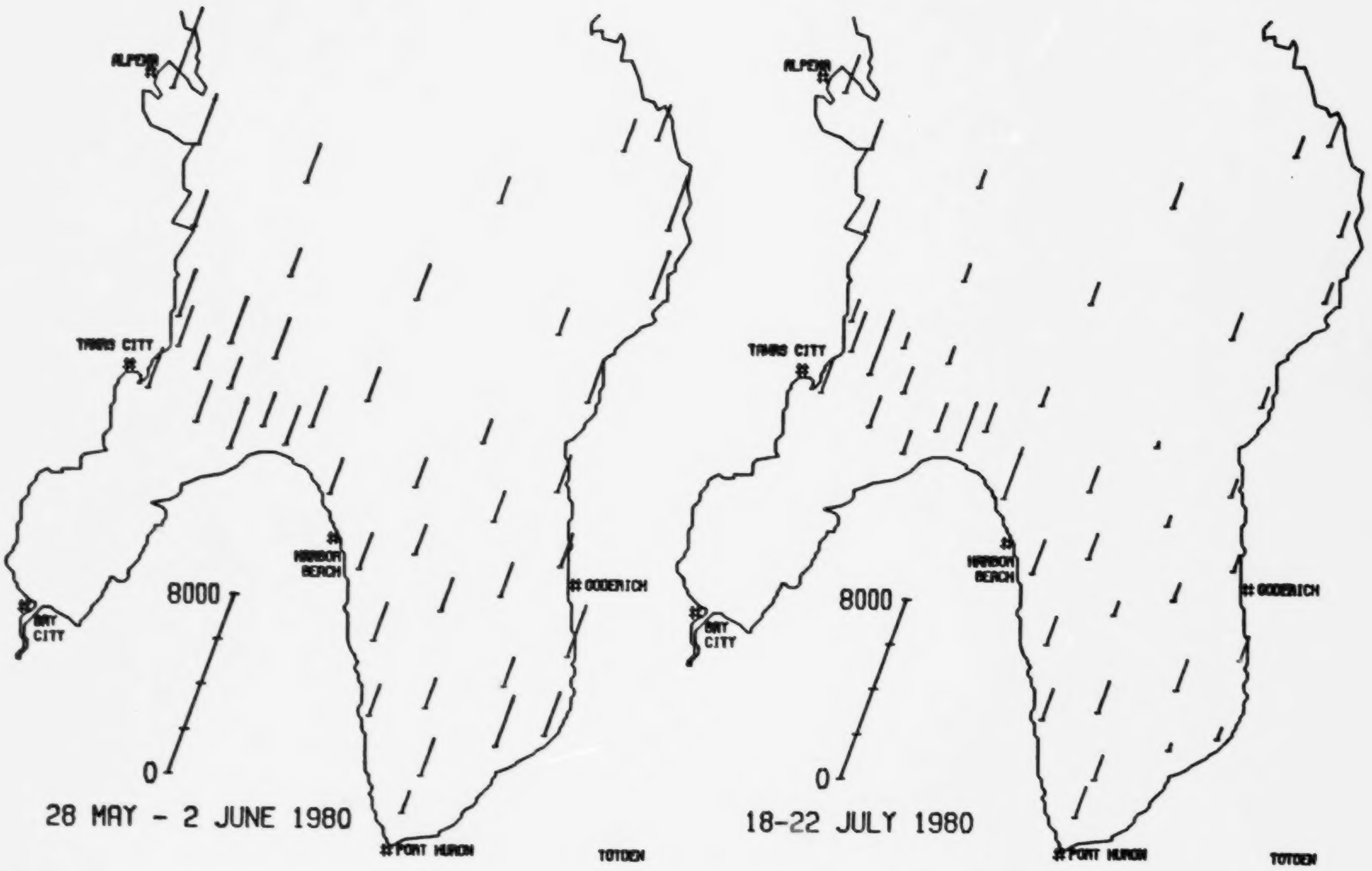
Figure 9. Seasonal Distribution and Abundance Trends of Total Phytoplankton Cell Densities.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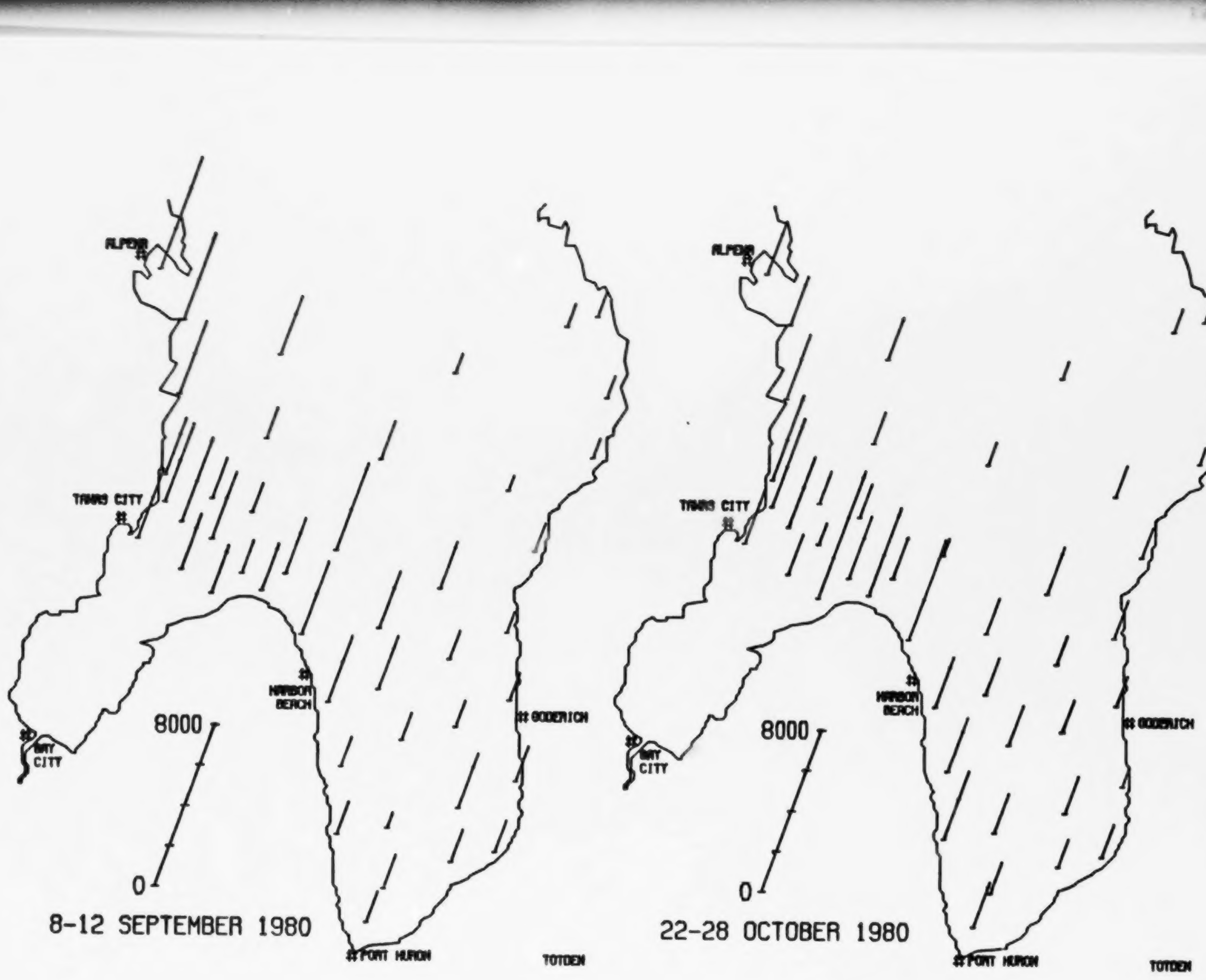
28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 9. (continued)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22-28 OCTOBER 1980

Figure 9. (continued)

entire study area with only slightly elevated cell numbers recorded for nearshore zones. During July (fig. 10D) highest abundances were seen in the U.S. sector of the lake in the nearshore areas extending slightly into offshore waters. Comparatively less abundance was seen in the Canadian sector and very low values were observed in the open waters of the central basin. Very low diatom cell numbers were observed over most of the study area in September (fig. 10E). On average, diatom abundance for September was the lowest for year. Large abundances were reported only for the nearshore zone between Alpena and Tawas City. In October largest average diatom abundance for the year was recorded. Greatest abundance was observed in Saginaw Bay however large abundances were recorded for the entire U.S. coastline from Alpena through outer Saginaw Bay to Port Huron (fig. 10). Much less abundance was observed in the offshore waters and the Canadian nearshore areas.

Asterionella formosa

This species is cosmopolitan, occurring in a number of different habitats and exhibiting a wide range of pollutional tolerance. It has previously been reported from all of the Great Lakes. During April (fig. 11A) it attained its greatest abundance in the southern basin, particularly along the U.S. sector of the basin. In May (fig. 11B) reduced abundances were seen in the southern basin and a comparatively larger standing crop was observed in the central basin. This trend was extended and amplified in

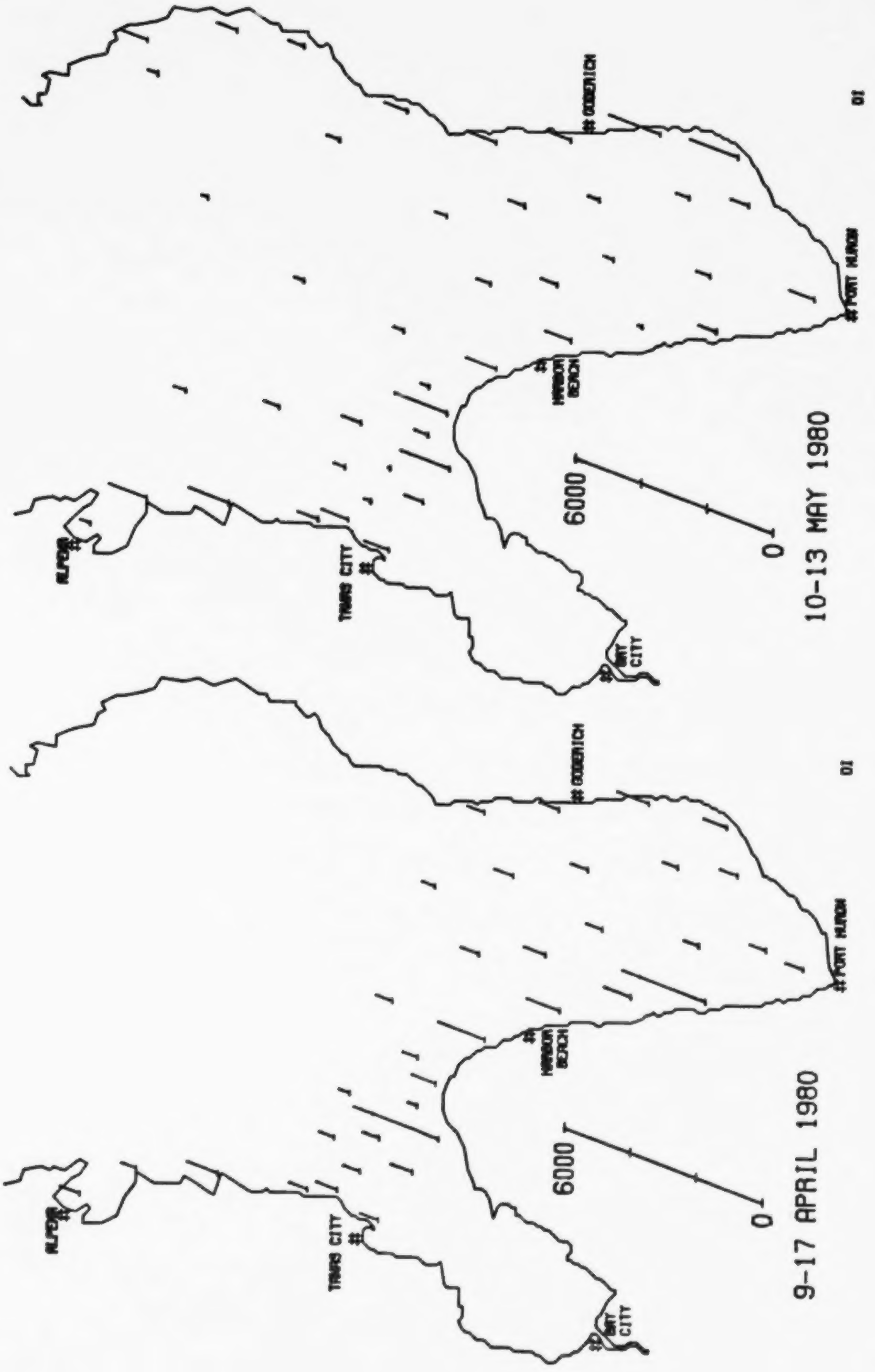
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Figure 10. Seasonal distribution and abundance trends of diatoms.

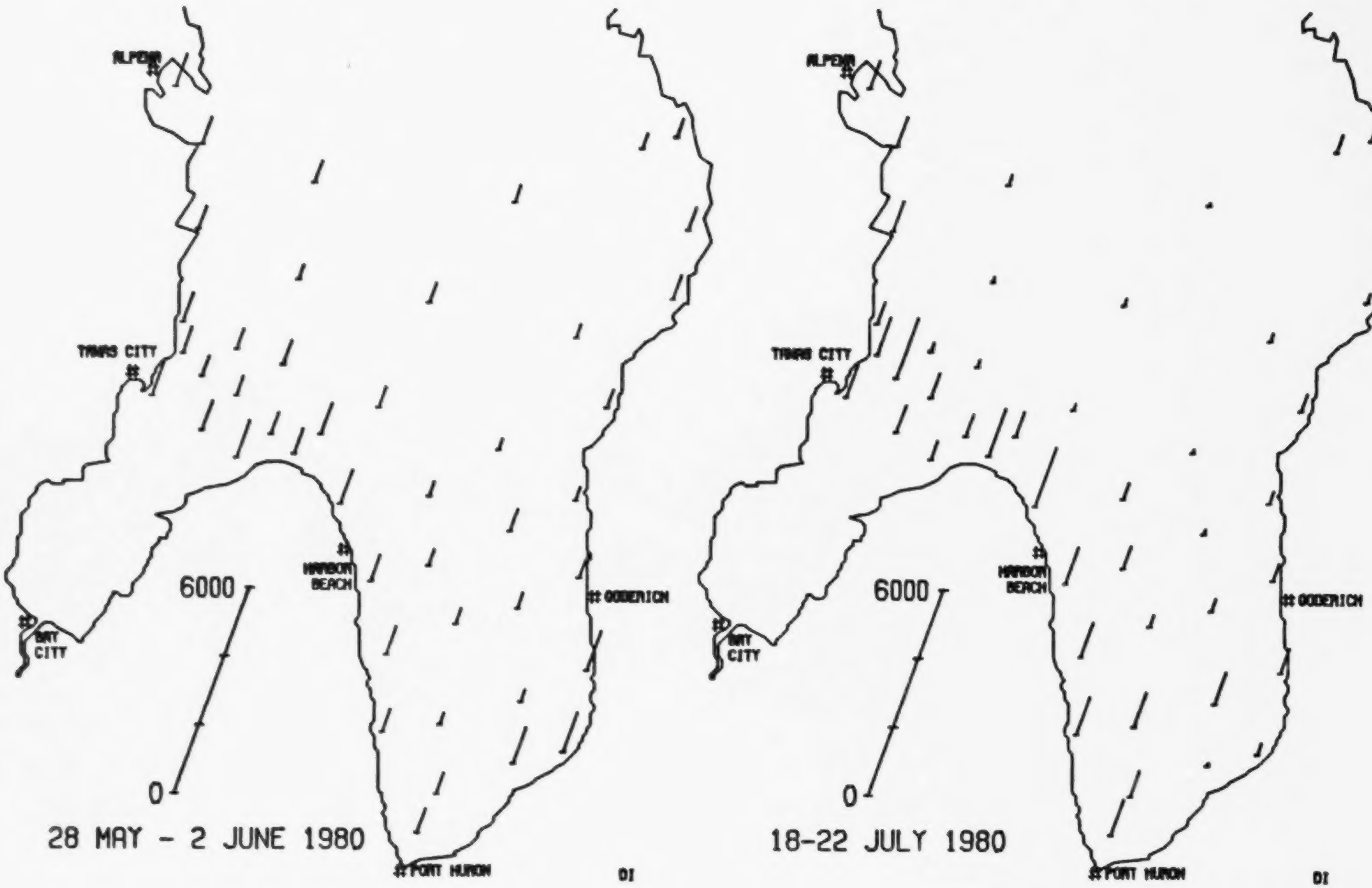
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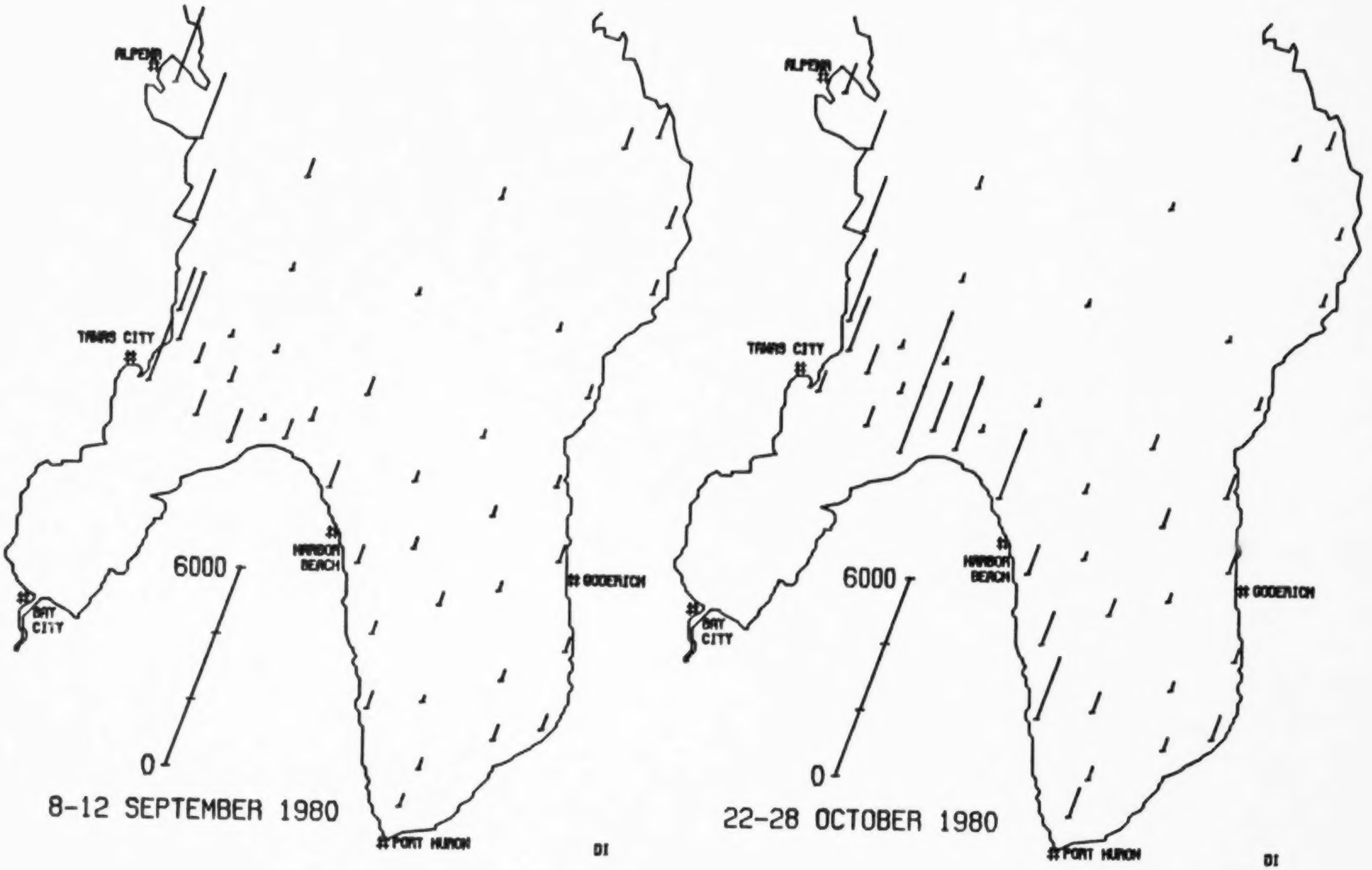
Figure 10. (continued)



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8-12 SEPTEMBER 1980

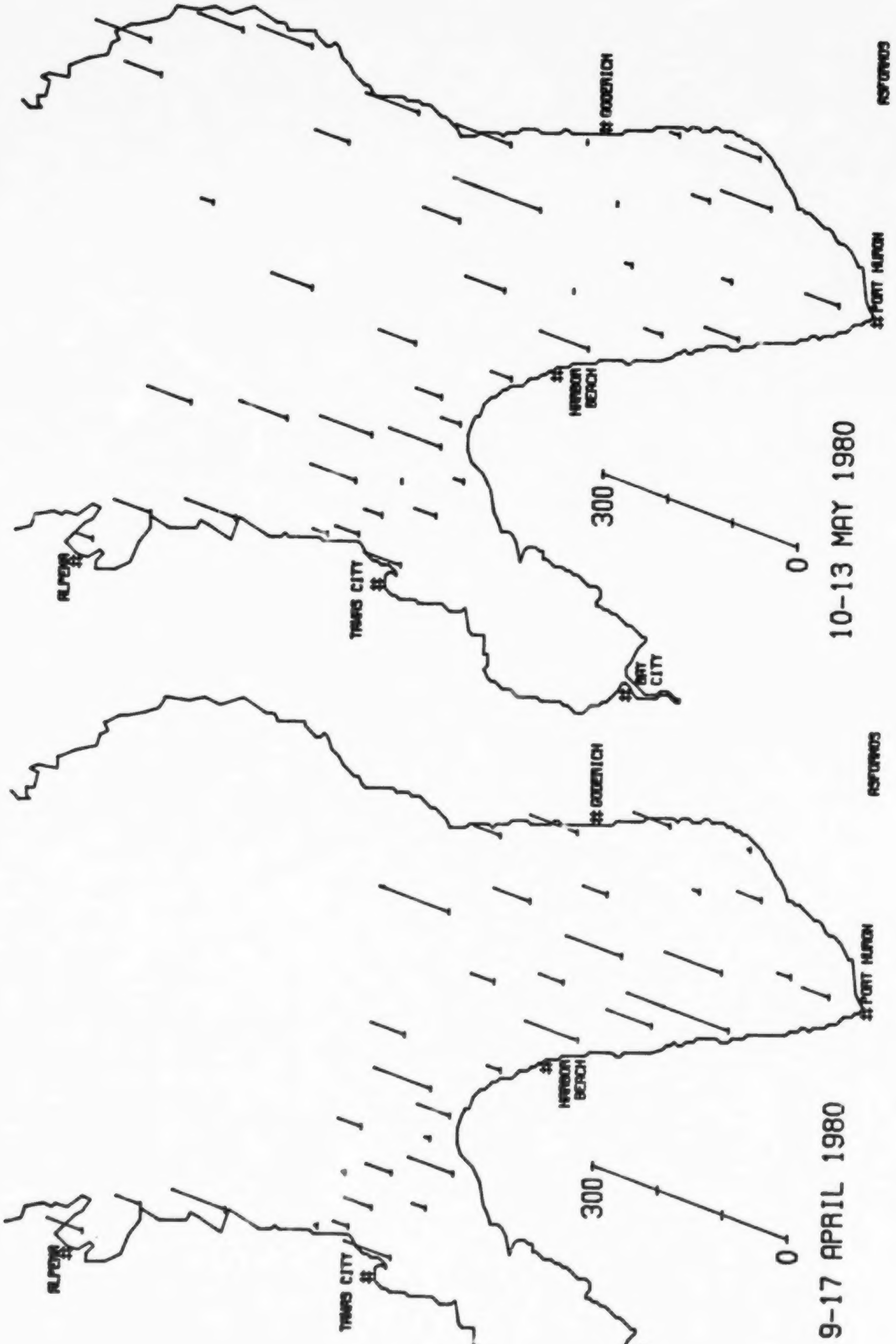
22-28 OCTOBER 1980

Figure 10. (continued)

June (fig. 11C) with highest standing crops in the central basin. Noteably reduced abundances were observed in July (fig. 11D) with the highest abundances occuring in the U.S. nearshore zone particularly south of Alpena. Continued abundance reduction was observed for September (fig. 11E) with most occurrences in nearshore areas. In October (fig. 11F) there were slight increases in standing crop in both basins with a high peak seen nearshore north of Goderich.

Cyclotella comensis

This species was recorded from the Great Lakes only in the past decade but has exhibited very large abundances in Lake Huron (Lowe 1976, Stoermer and Kreis 1980, Ladewski et al. 1982). In April (fig. 12A) abundances were low showing a uniform distribution. In May (fig. 12B) reduced abundances were observed yet it was widely distributed with highest standing crops reported between Alpena and Tawas City. During June (fig. 12C) highest cell numbers were observed along the entire U.S. shoreline and the Saginaw Bay interface waters. Generally, the offshore waters of both basins show low, uniform abundances. Increased abundances were noted in July (fig. 12D) particularly in the Saginaw Bay interface waters and in the southern basin. Very low abundances were seen in the offshore waters of the central basin. Largest standing crops for the year were seen during September (fig. 12E). Large concentrations of this species were seen between Alpena and Tawas City with reduced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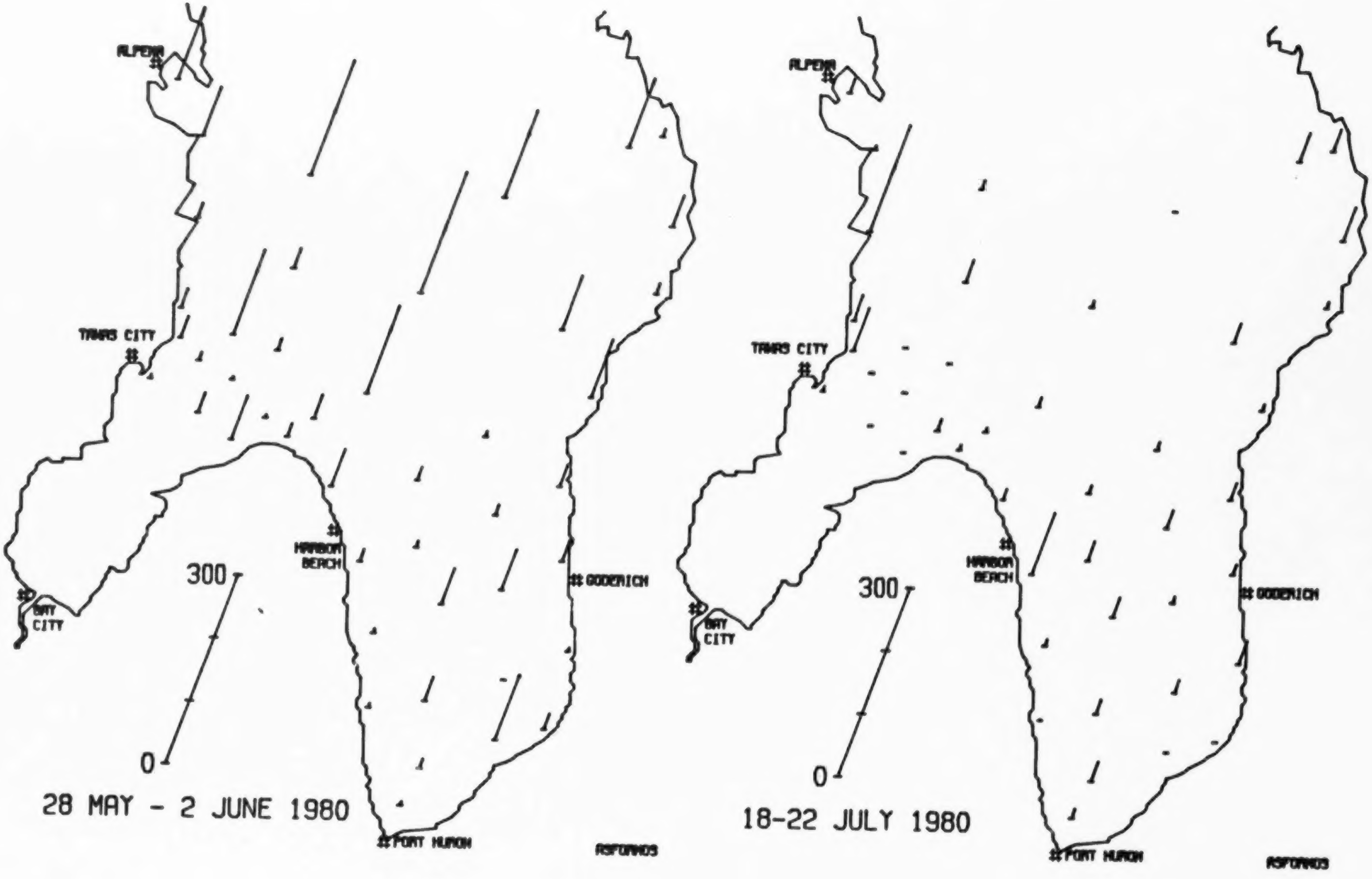
10-13 MAY 1980

Figure 11. Distribution of Asterionella formosa.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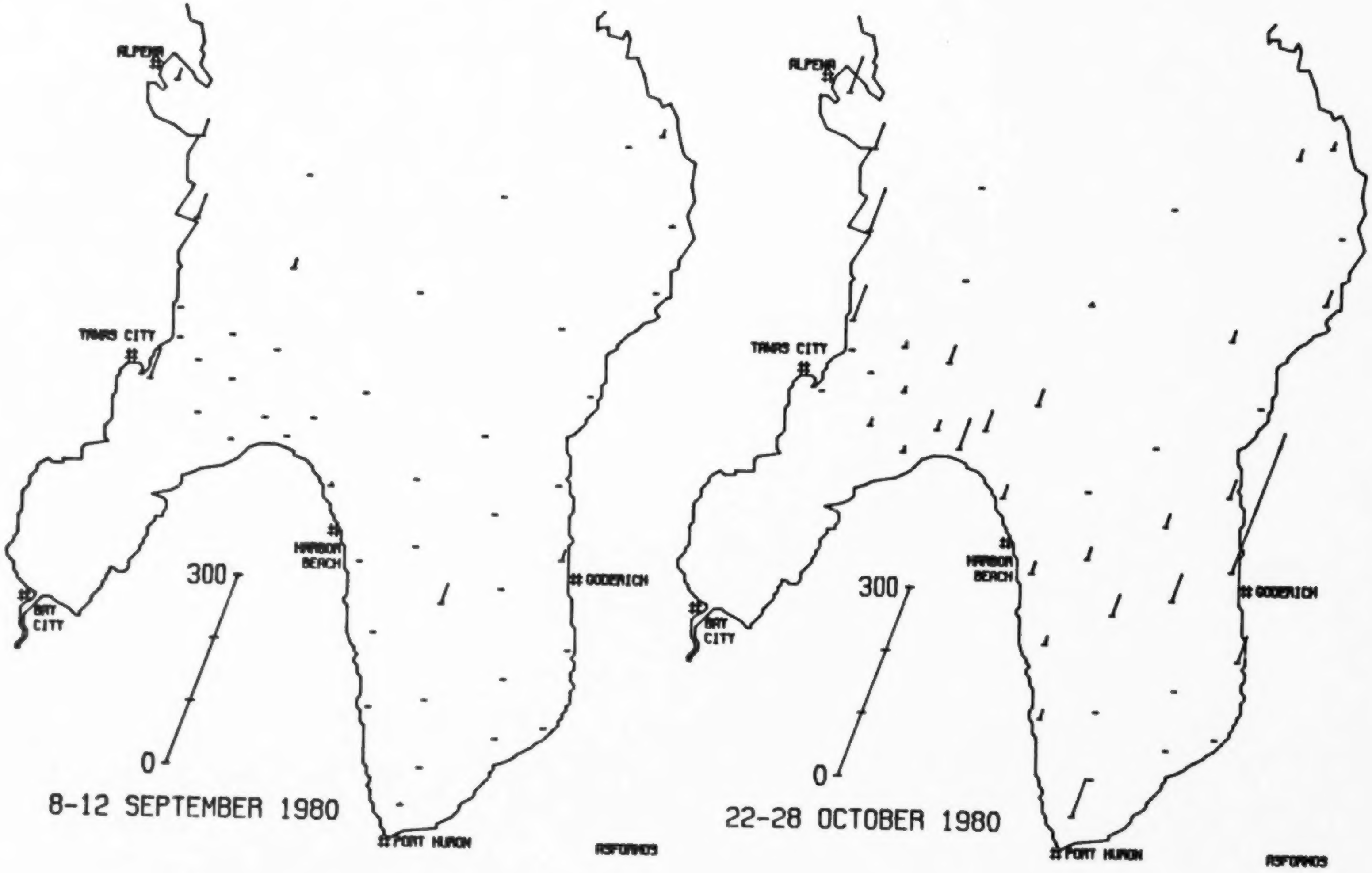
28 MAY - 2 JUNE 1980
18-22 JULY 1980

Figure 11. (continued)



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GODERICH
PORT HURON
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8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 11. (continued)

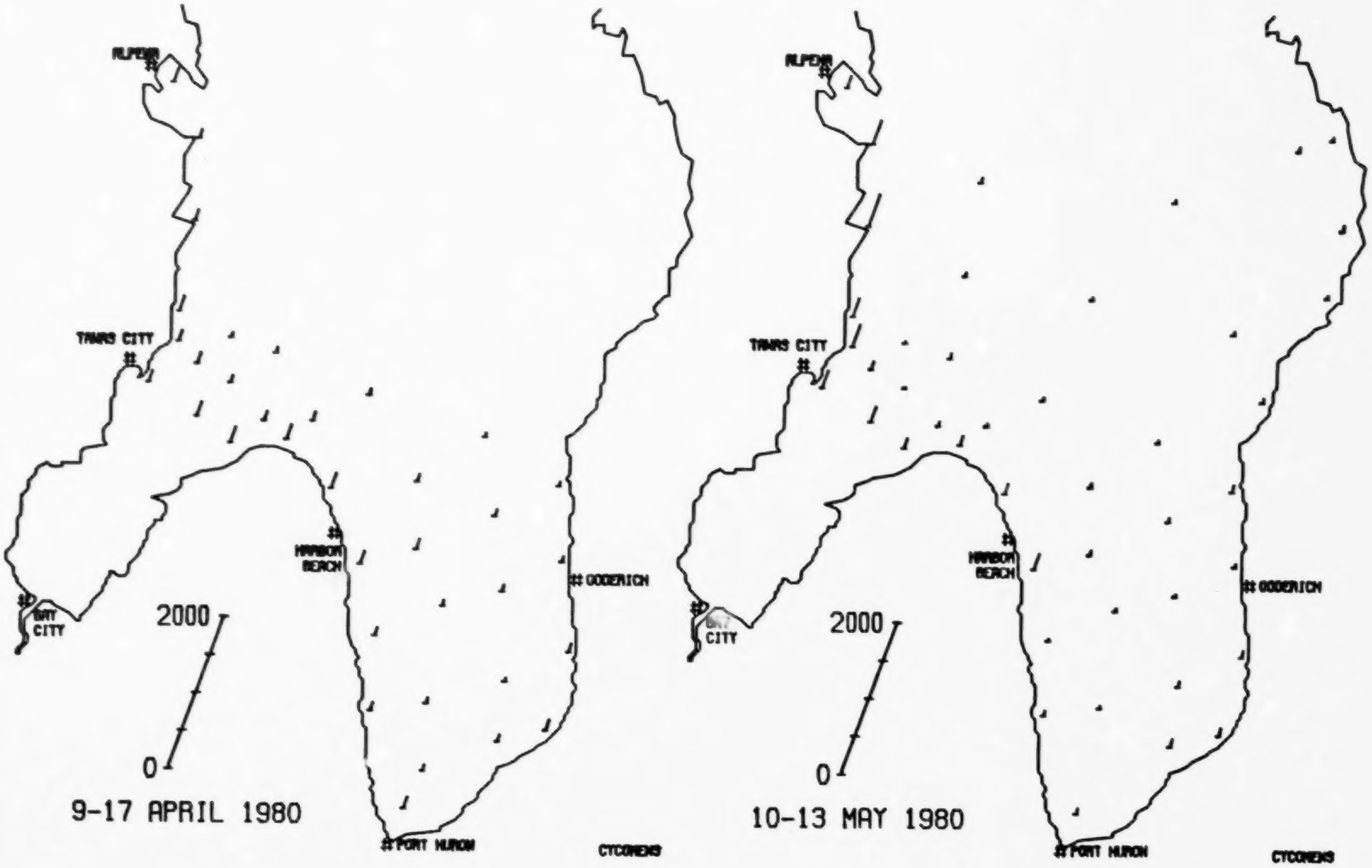
abundances in the southern basin. Highest abundances in the open central basin were also noted during this month. Standing crops were generally reduced during October (fig. 12F) with highest abundance seen in the U.S. section of the lake.

Cyclotella comta

Cyclotella comta is commonly noted in the plankton of the Great Lakes but is reduced in areas that have been adversely impacted. During April through June (figs. 13A-13C) it showed very low abundances and sporadic occurrences at stations in outer Saginaw Bay and in the interface zone. In July (fig. 13D) it was observed in the northern Canadian shoreline and slightly elevated abundances were seen in outer Saginaw Bay and particularly along the coastline north of Tawas City. It reached its maximum abundance and widest distribution for the year in September (fig. 13E) with highest abundances being observed north of Tawas City along the shore and in the western sector of the central basin. Reduced abundances and distribution were recorded for October (fig. 13F) with highest abundances seen in the mid-central basin.

Cyclotella michiganiana

This diatom was originally found and described from Lake Michigan by Skvortzow (1937). It has also been observed in the inland lakes of the state of Michigan (Stoermer 1977, Andresen and Stoermer 1978). In April (fig. 14A) this species reached its greatest abundance for



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ALPENA
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BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CYCOMENS
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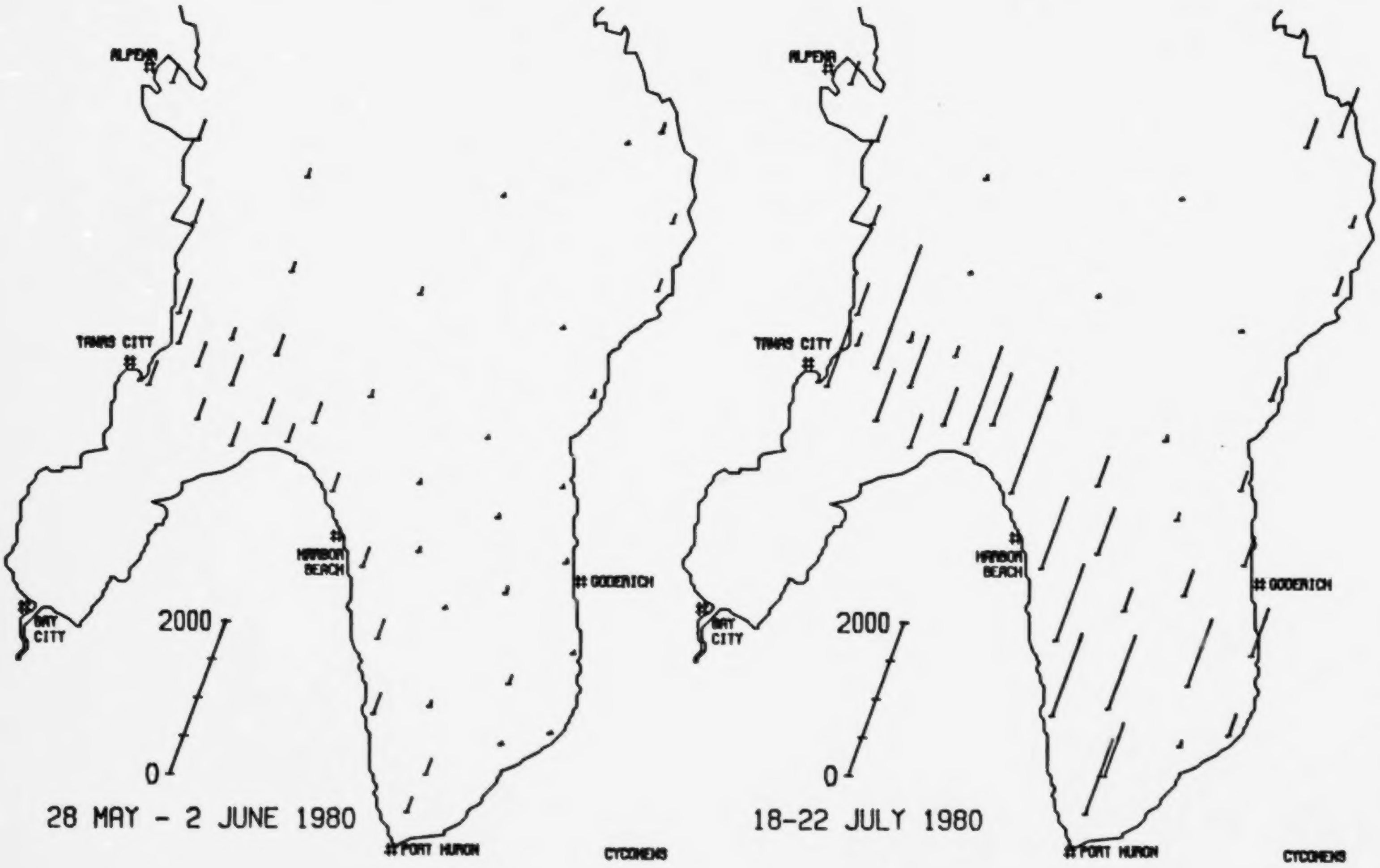
10-13 MAY 1980

Figure 12. Distribution of Cyclotella comensis.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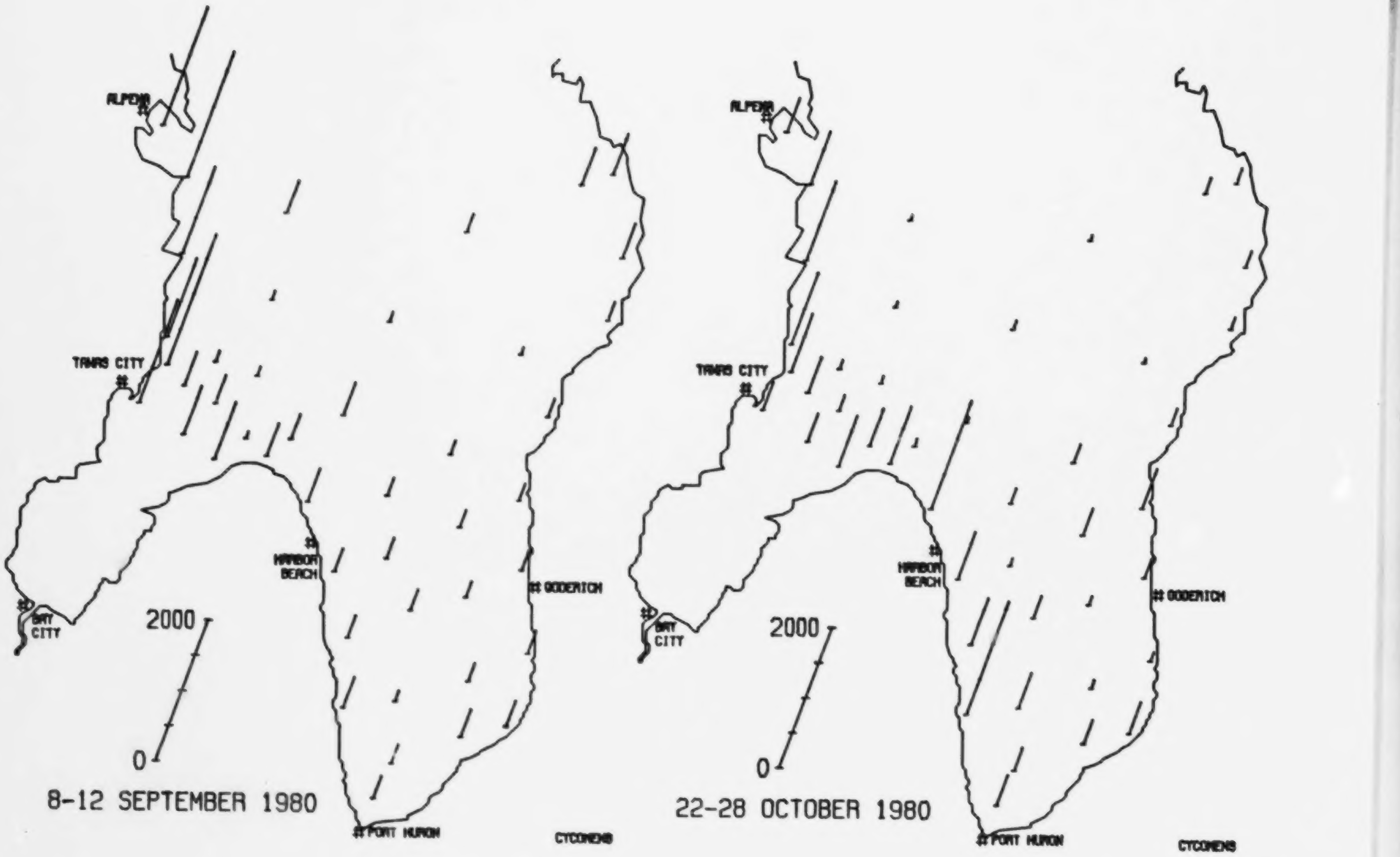
18-22 JULY 1980
CYCOMENS

Figure 12. (continued)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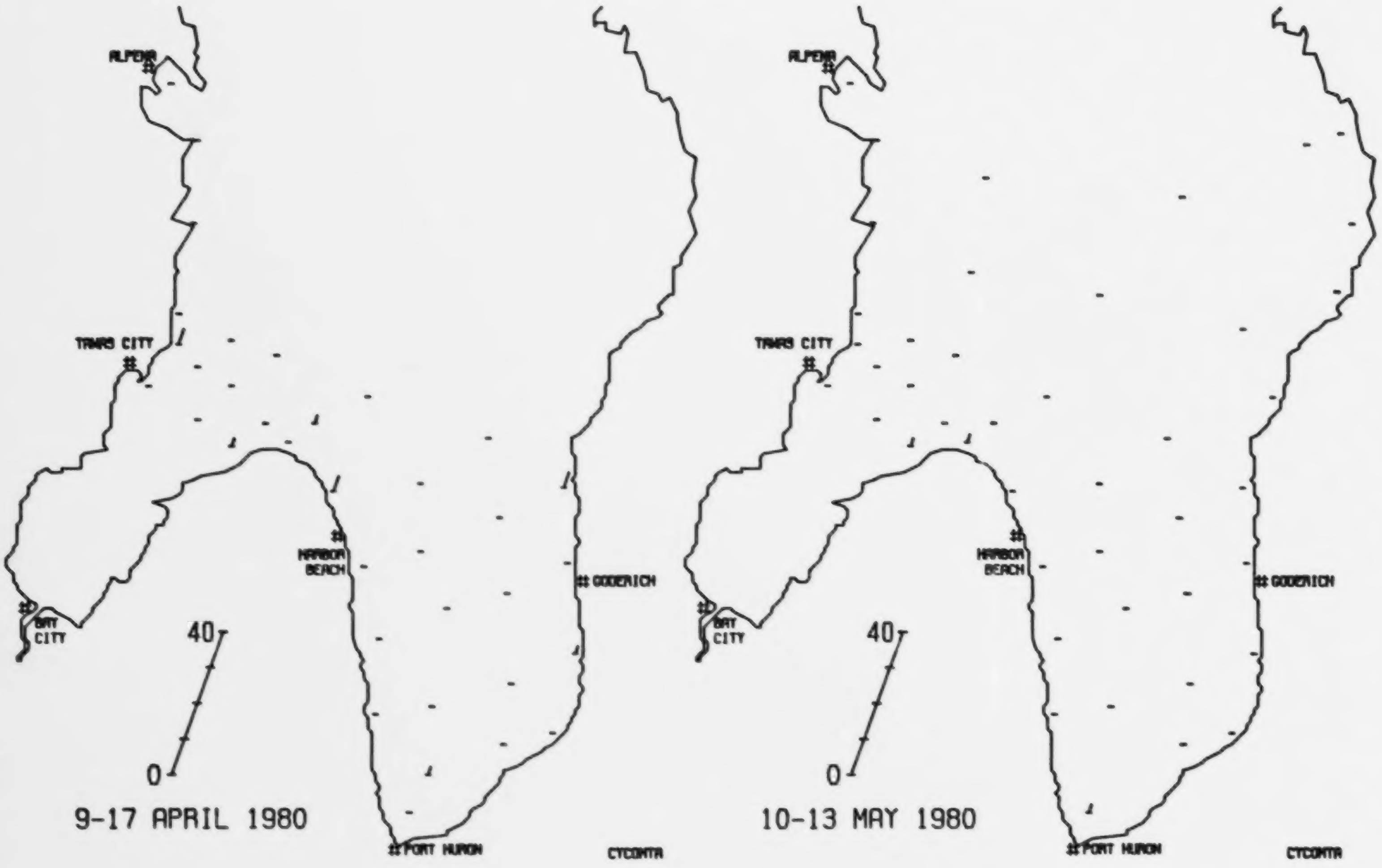
8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 12. (continued)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GODERICH
PORT HURON
CYCOMTA
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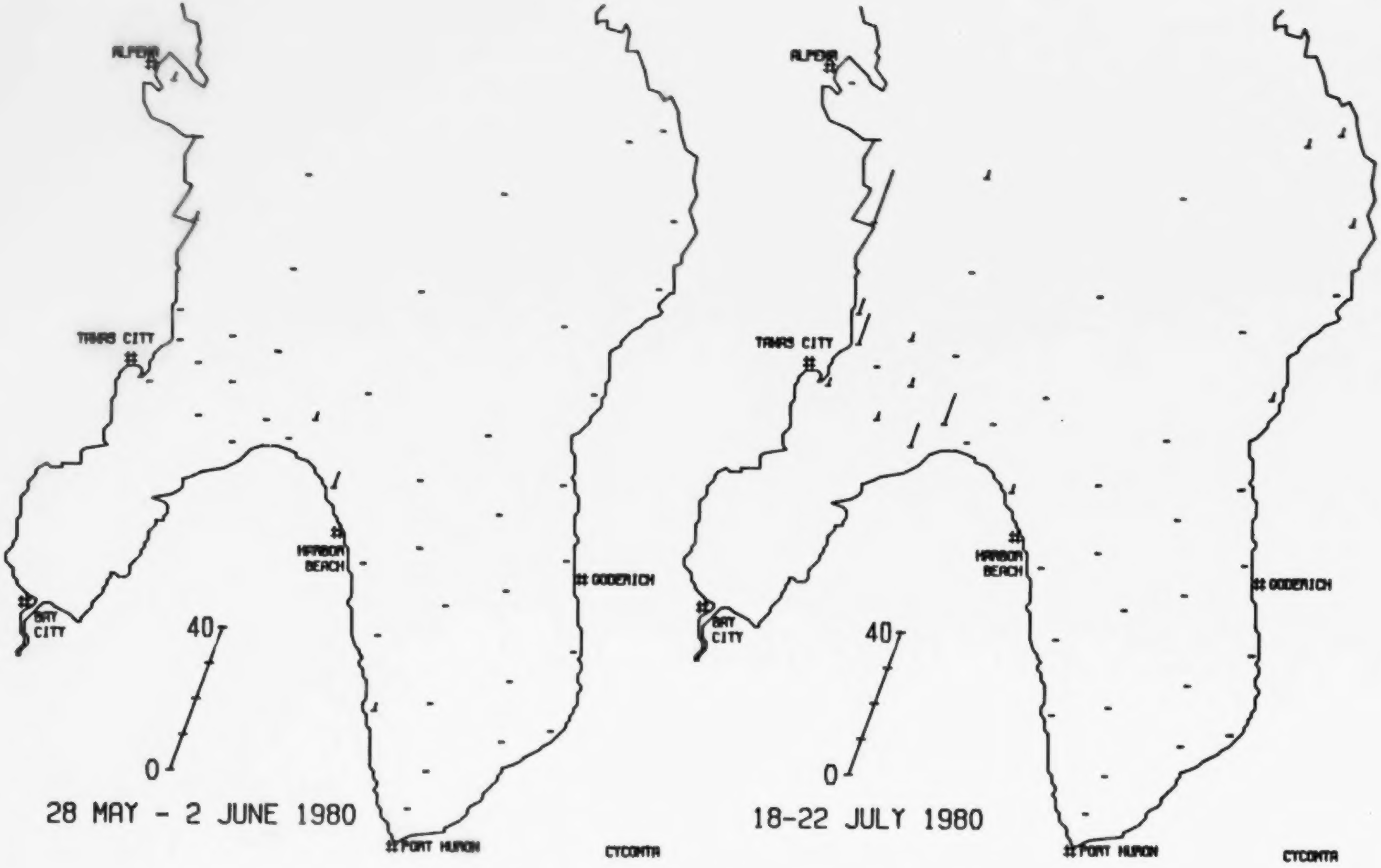
10-13 MAY 1980

Figure 13. Distribution of Cyclotella comta.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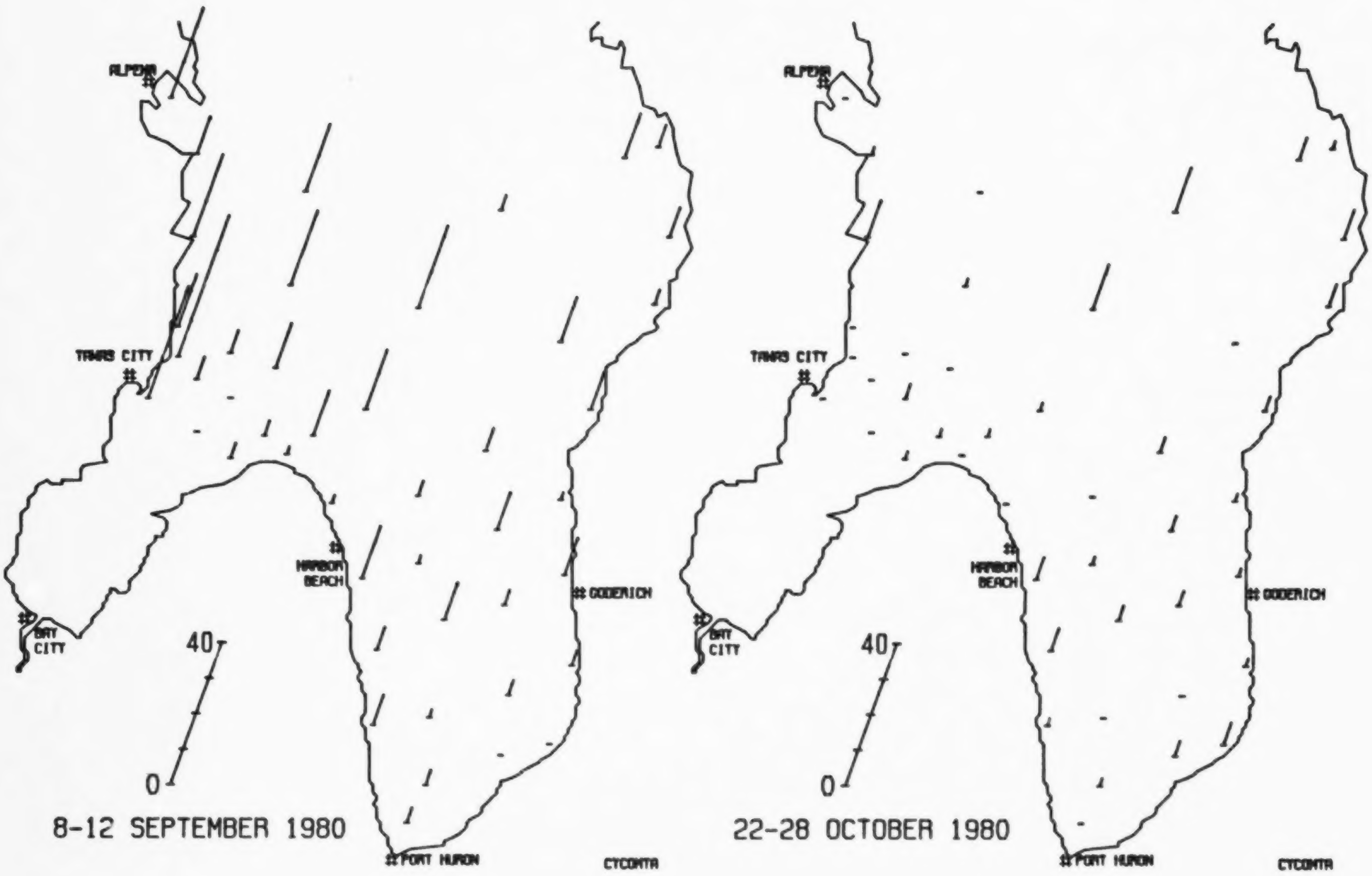
28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 13. (continued)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8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 13. (continued)

the season. It occurred in the nearshore areas on the U.S. sector with highest abundance in outer Saginaw Bay and southward. It was substantially reduced in abundance in May (fig. 14B) but was widely distributed over the study area. Low abundances were seen in June (fig. 14C) with most occurrences restricted to the offshore waters of the southern basin. During July (fig. 14D) low abundances were again observed with most occurrences in the central basin. During September (fig. 14E) slightly higher abundances were observed with highest peaks in the nearshore zone between Alpena and Tawas City. In October (fig. 14F) occurrences were predominantly in the nearshore zone of the U.S. sector.

Cyclotella _ocellata_

Populations of this centric diatom are usually associated with periods of cooler water temperatures and are also observed during upwelling events and near the thermocline in the Great Lakes. It is an important component of assemblages in northern Lake Huron (Stoermer _et al_. 1976). Stoermer and Yang (1968) also found this species to be the dominant in their core from northern Lake Huron. In April (fig. 15A) _C_. _ocellata_ was observed in high abundances showing a wide, uniform distribution over the sample area with peaks in the Canadian nearshore, the northern U.S. coast and in the open southern basin. Reduced abundances were observed in May (fig. 15B) with highest abundances in the western section of the central basin. It showed higher abundances in the offshore waters of the

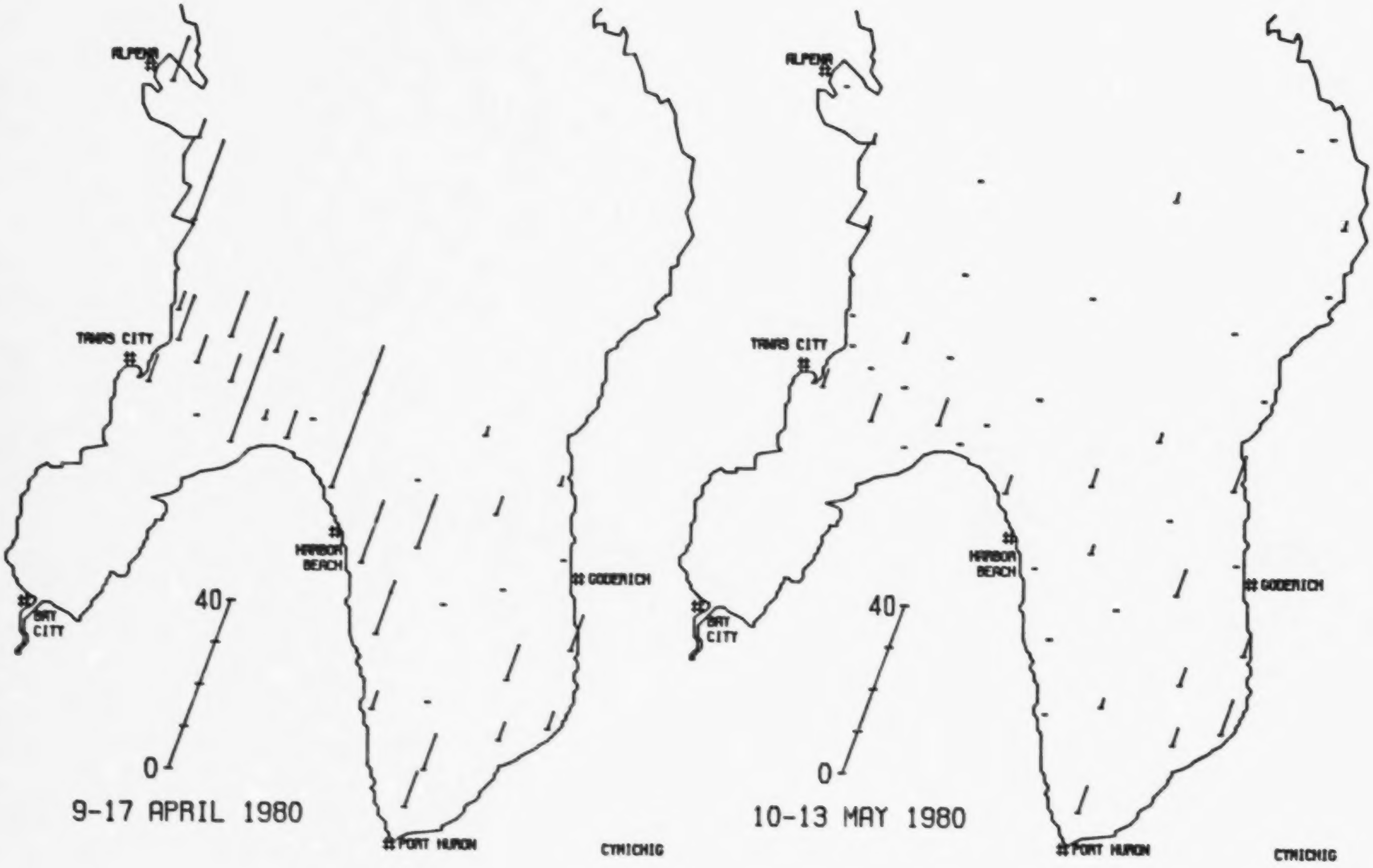
ALPENA
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Figure 14. Distribution of Cyclotella michiganiana.

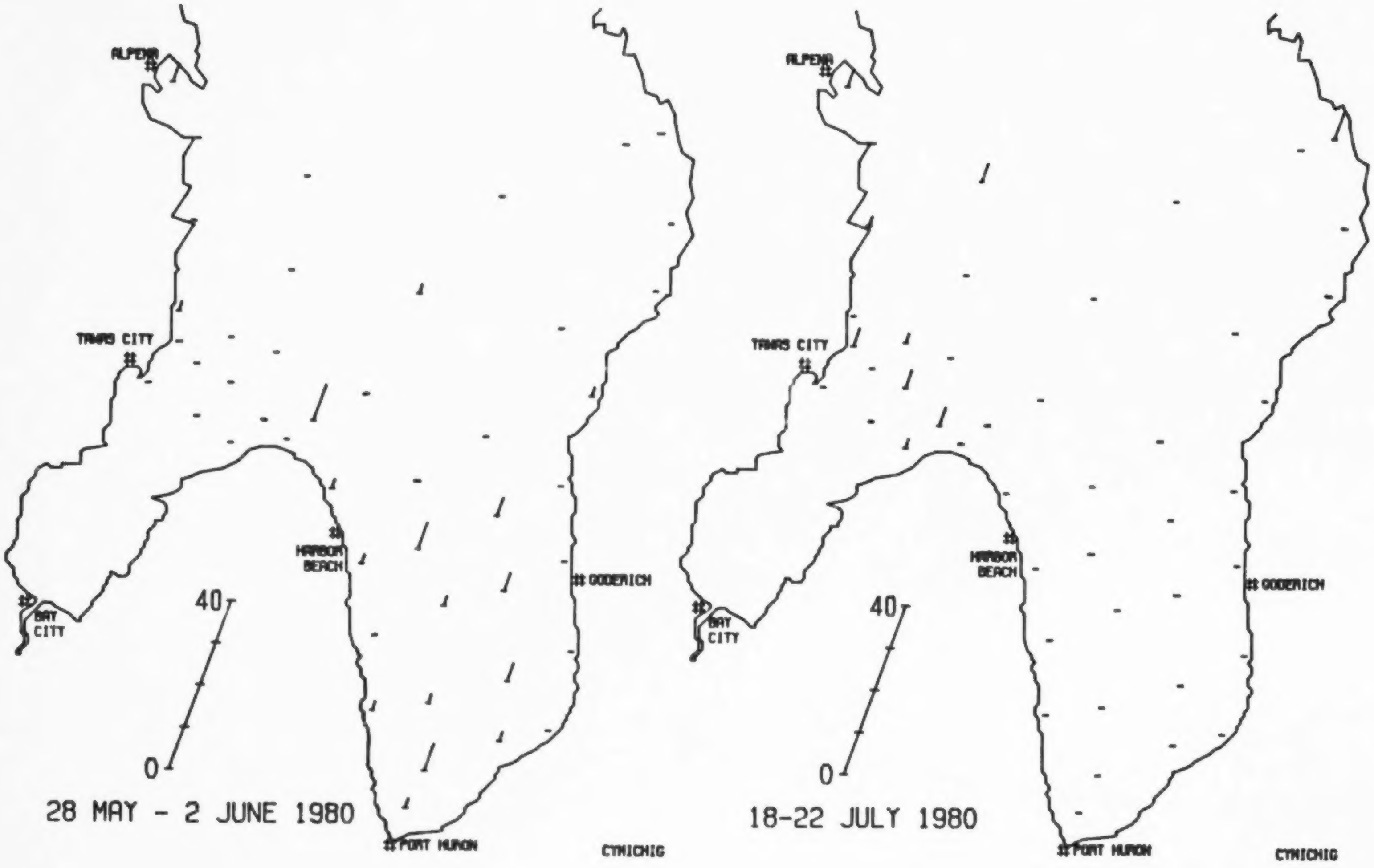
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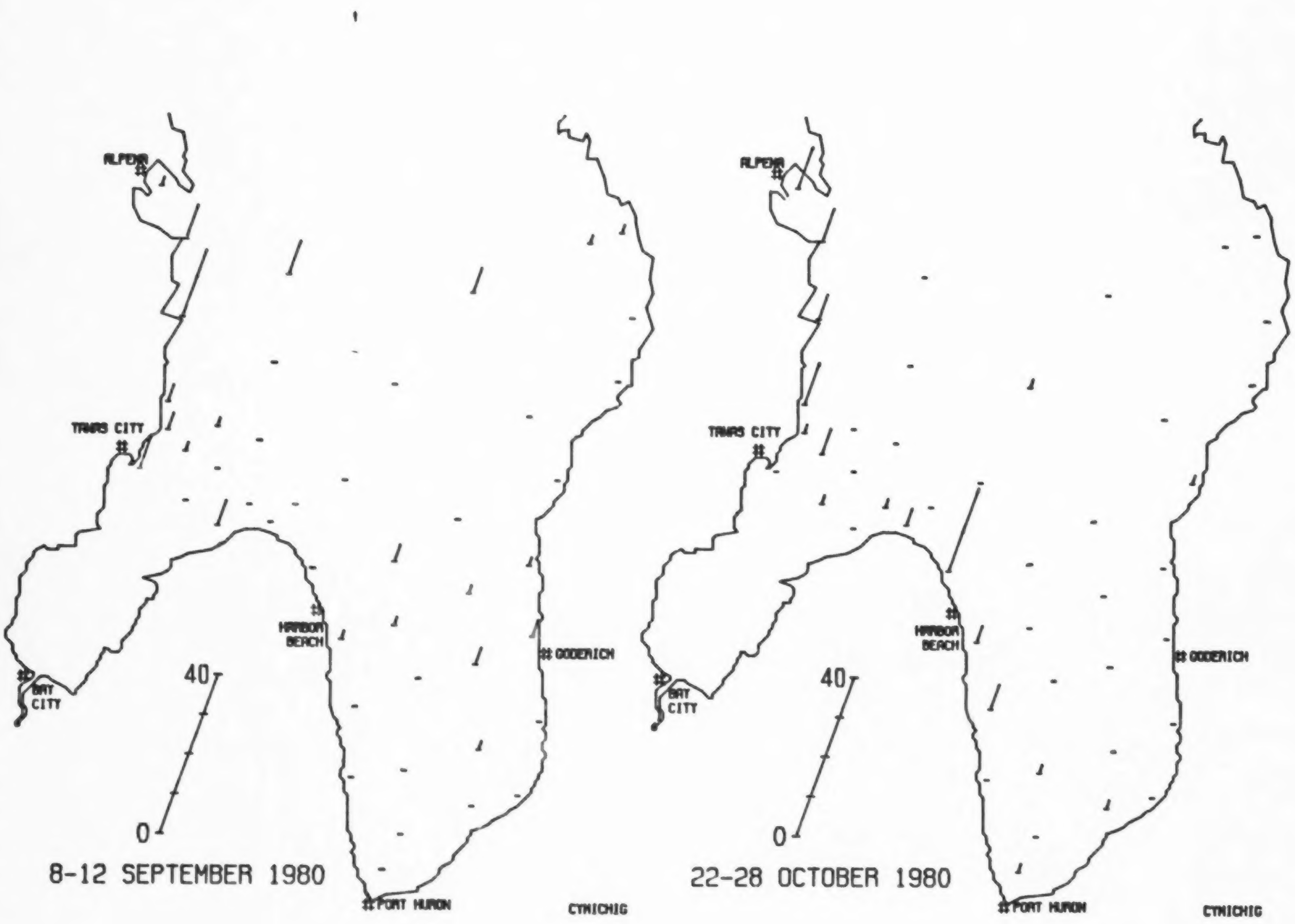
Figure 14. (continued)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8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 14. (continued)

southern basin compared to the nearshore zone. In June (fig. 15C) increased abundances were seen lakewide with higher standing crops observed in the U.S. sector of the lake. During July (fig. 15D) this species was nearly eliminated from the southern basin with greatest abundances in the open central basin. During September (fig. 15E) populations were substantially reduced over the entire area with only sporadic occurrences. Slightly elevated abundance and a wide distribution were exhibited in October (fig. 15F) with highest abundances in the open waters.

Cyclotella _pseudostelligera_

This taxon generally attains its greatest abundance in nearshore areas and is associated with rivermouth outflows in the Great Lakes. However during this study, it extended its distribution into the open waters. This taxon was not observed until June (fig. 16A) when it was only recorded from two stations in the Canadian nearshore area. In July (fig. 16B) highest abundances were seen in the nearshore zone between Alpena and Tawas City and the Saginaw Bay interface area. _C_. _pseudostelligera_ increased to its highest abundance and widest occurrence in September (fig. 16C). It was distributed over the entire southern basin with highest peaks on the Canadian nearshore sector. It also was observed in nearshore zones in the central basin. In October (fig. 16D) it was greatly reduced in abundance with only a few scattered occurrences in littoral areas.

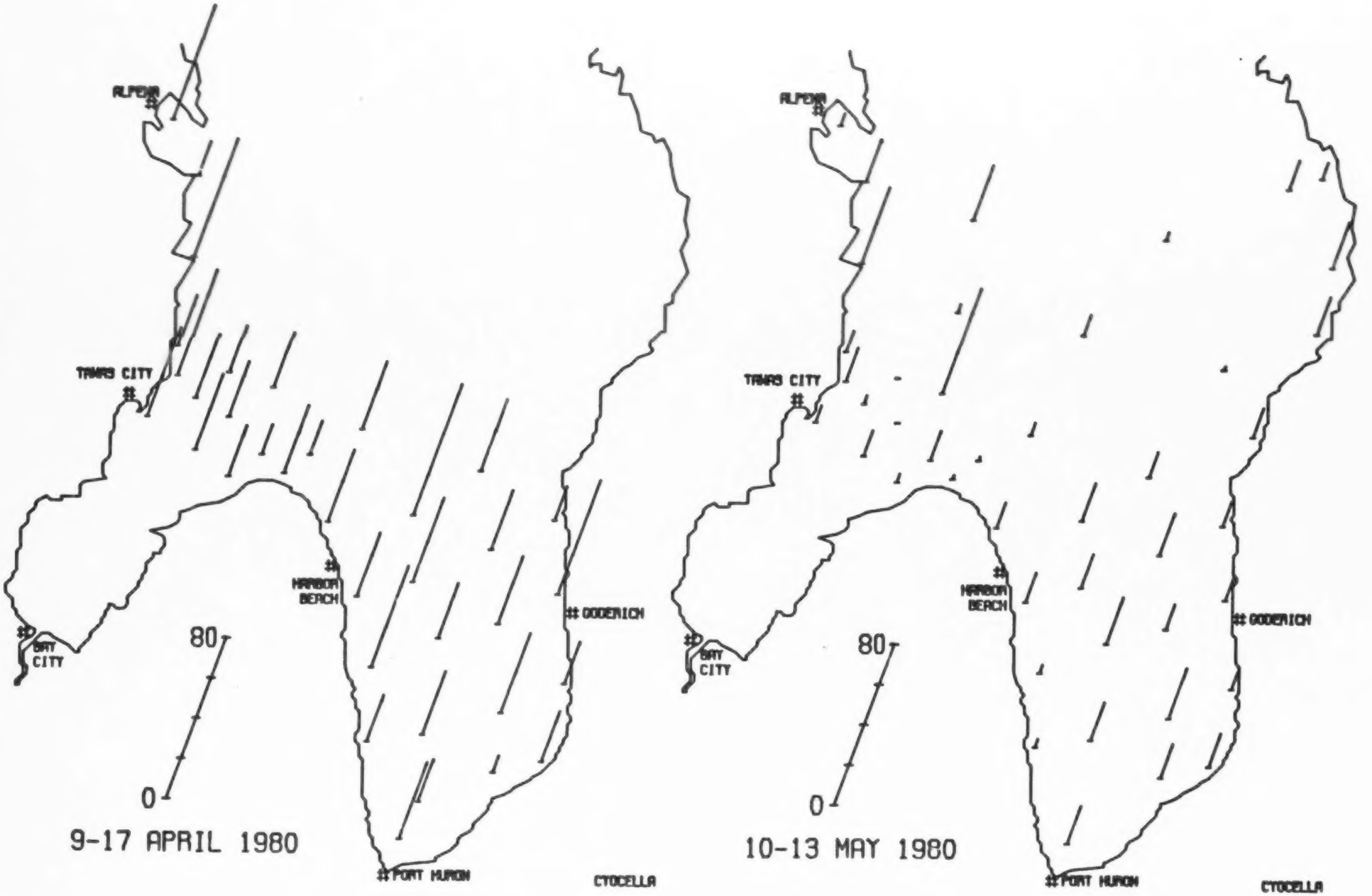
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Figure 15. Distribution of Cyclotella ocellata.

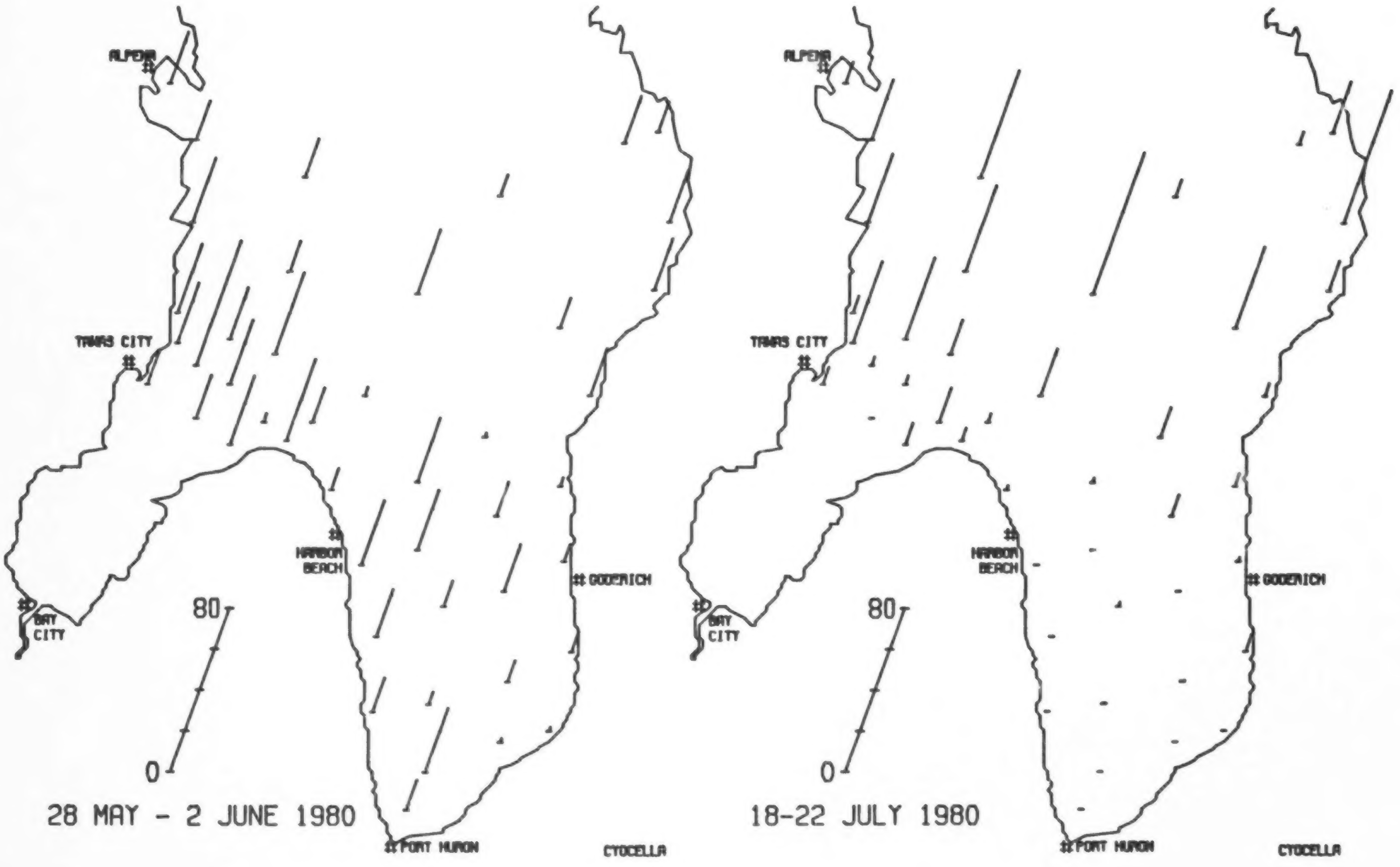
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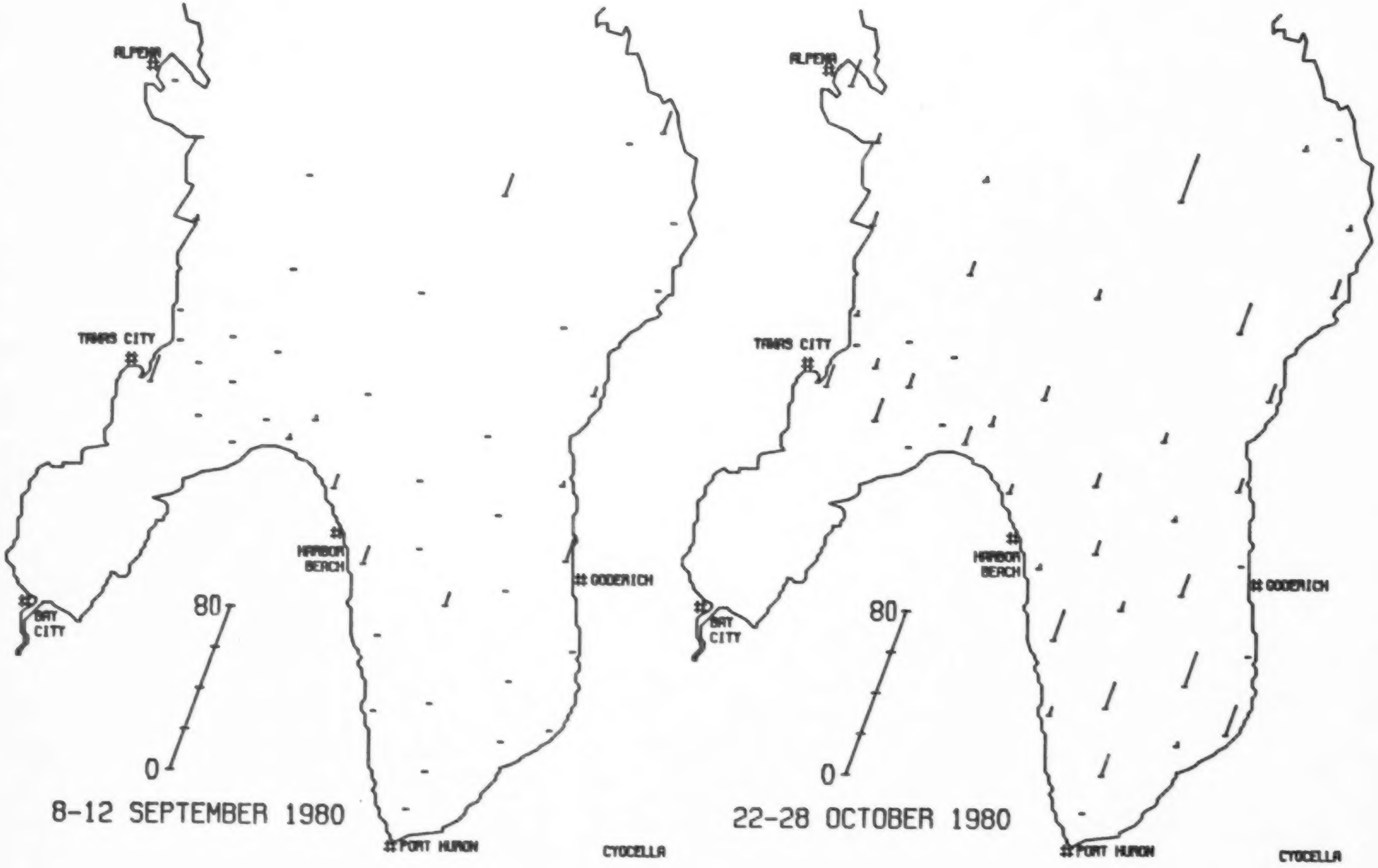
Figure 15. (continued)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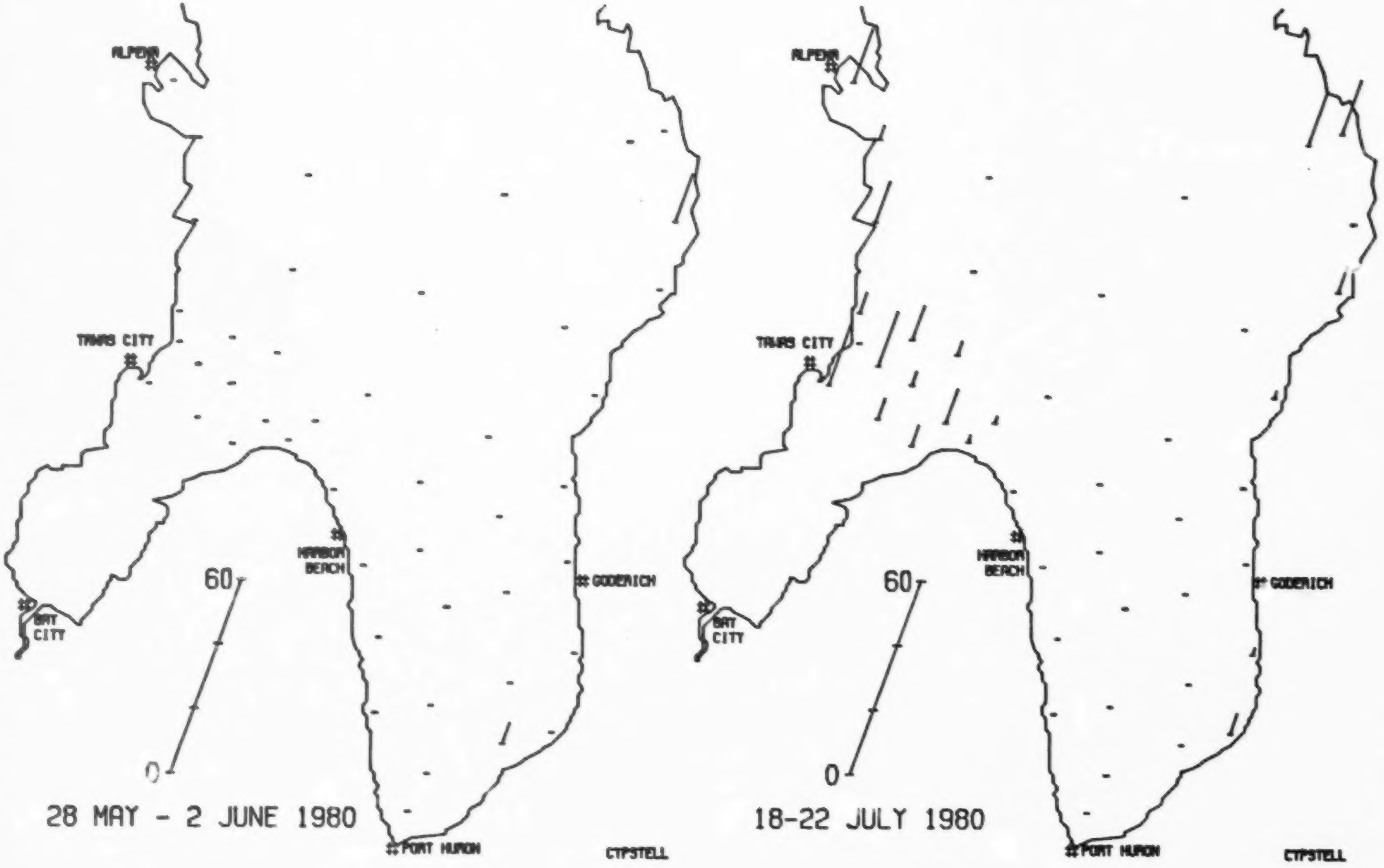
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
80
0
22-28 OCTOBER 1980
CYOCELLA

Figure 15. (continued)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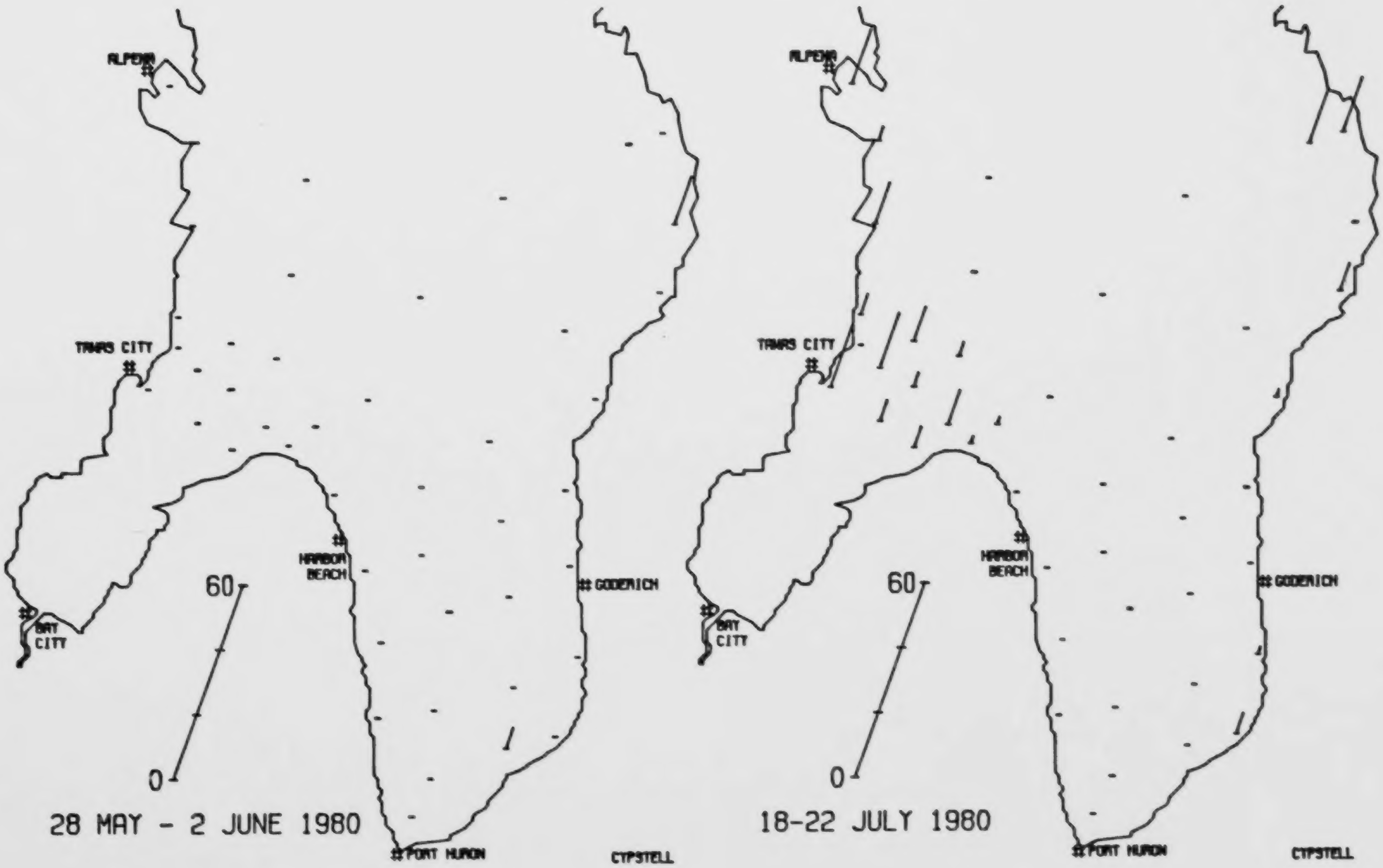
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
28 MAY - 2 JUNE 1980
CYPSTELL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
18-22 JULY 1980
CYPSTELL

Figure 16. Distribution of Cyclotella pseudostelligera.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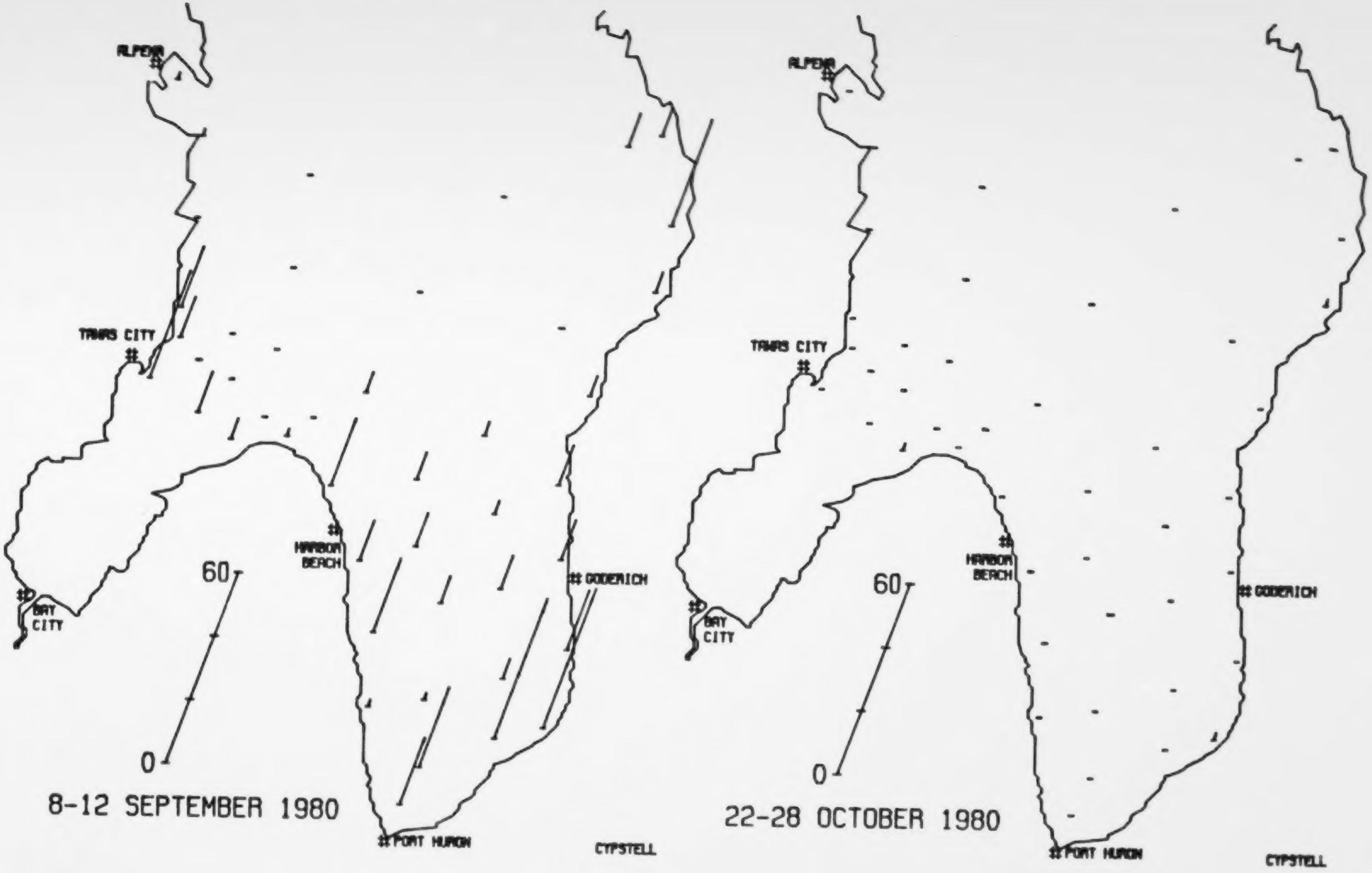
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
60
0
28 MAY - 2 JUNE 1980
CYPSTELL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
60
0
18-22 JULY 1980
CYPSTELL

Figure 16. (continued)



8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CYPSTELL
60
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CYPSTELL
60
0

Figure 16. (continued)

Cyclotella stelligera

This species is commonly reported from the Great Lakes and although it is found in oligotrophic assemblages it may respond to slight nutrient enrichment (Schelske *et al*. 1972). In April (fig. 17A) *C*. *stelligera* was uniformly distributed with slightly higher abundances in the northern U.S. shoreline and in the open southern basin . Reduced abundances were noted in May (fig. 17A) but it was widely distributed however in no distinct pattern. During June (fig. 17C) increased abundances were noted, particularly on the shoreline between Alpena and Tawas City, however still showing a wide distribution. Largest abundances for the season were noted in July (fig. 14D) it was particularly abundant in the north U.S. nearshore zone and in the Saginaw Bay interface. Reduced abundances were noted in September (fig.14E) but conversely to the preceeding month, with greatest abundance occuring in the east sector of the central basin. Comparatively, lower abundance was observed for October (fig. 14F) with no apparent distributional trend.

Diatoma tenue var. *elongatum*

This species is associated with enriched conditions and as noted during this study finds its greatest abundance in the spring. Largest populations were seen in April (fig. 18A) particularly in outer Saginaw Bay and the nearshore zone south of the bay. Reduced abundances but a wider distribution was observed in May (fig. 18B) with

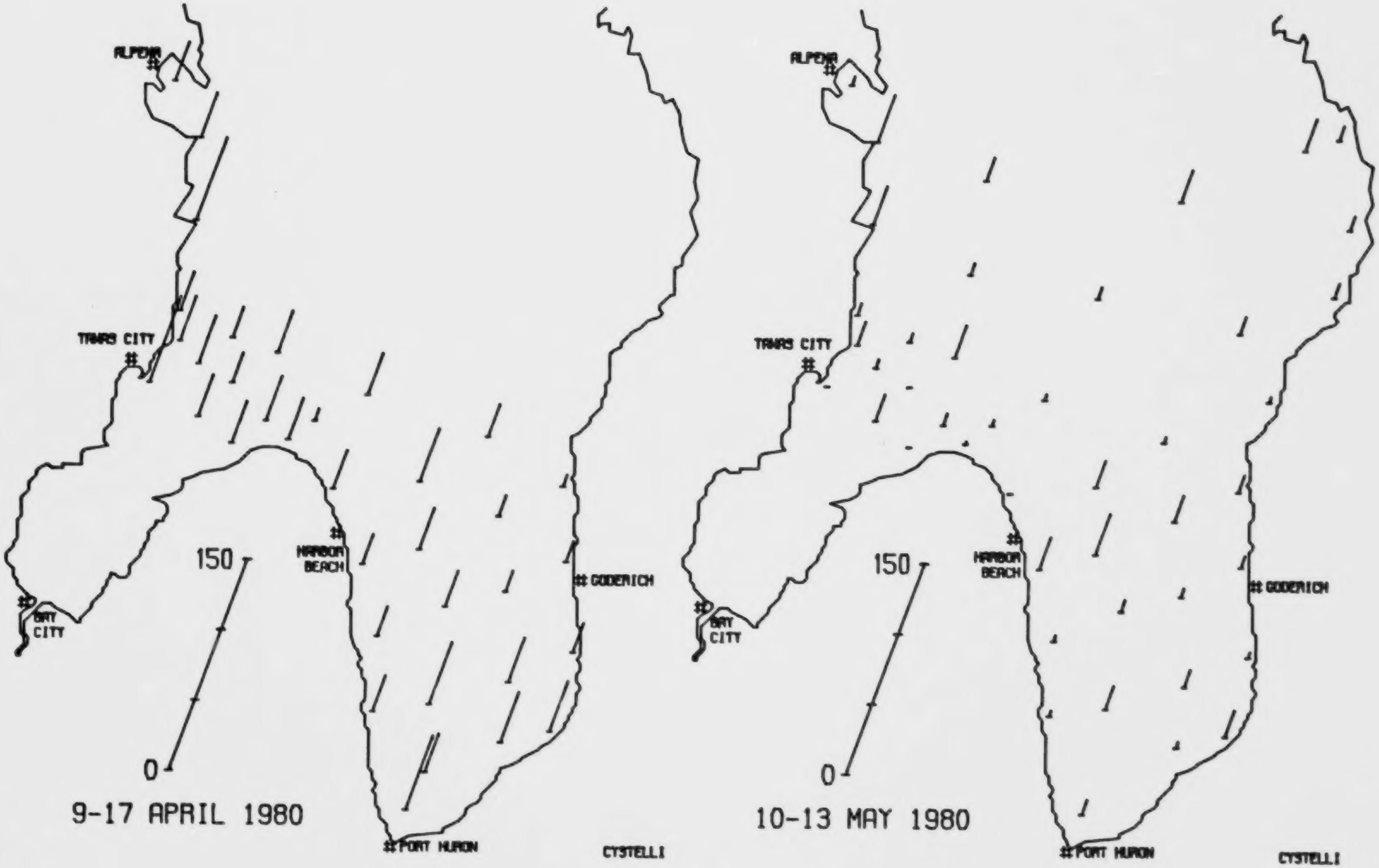

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
9-17 APRIL 1980
CYSTELLI
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
10-13 MAY 1980
CYSTELLI

Figure 17. Distribution of Cyclotella stelligera.

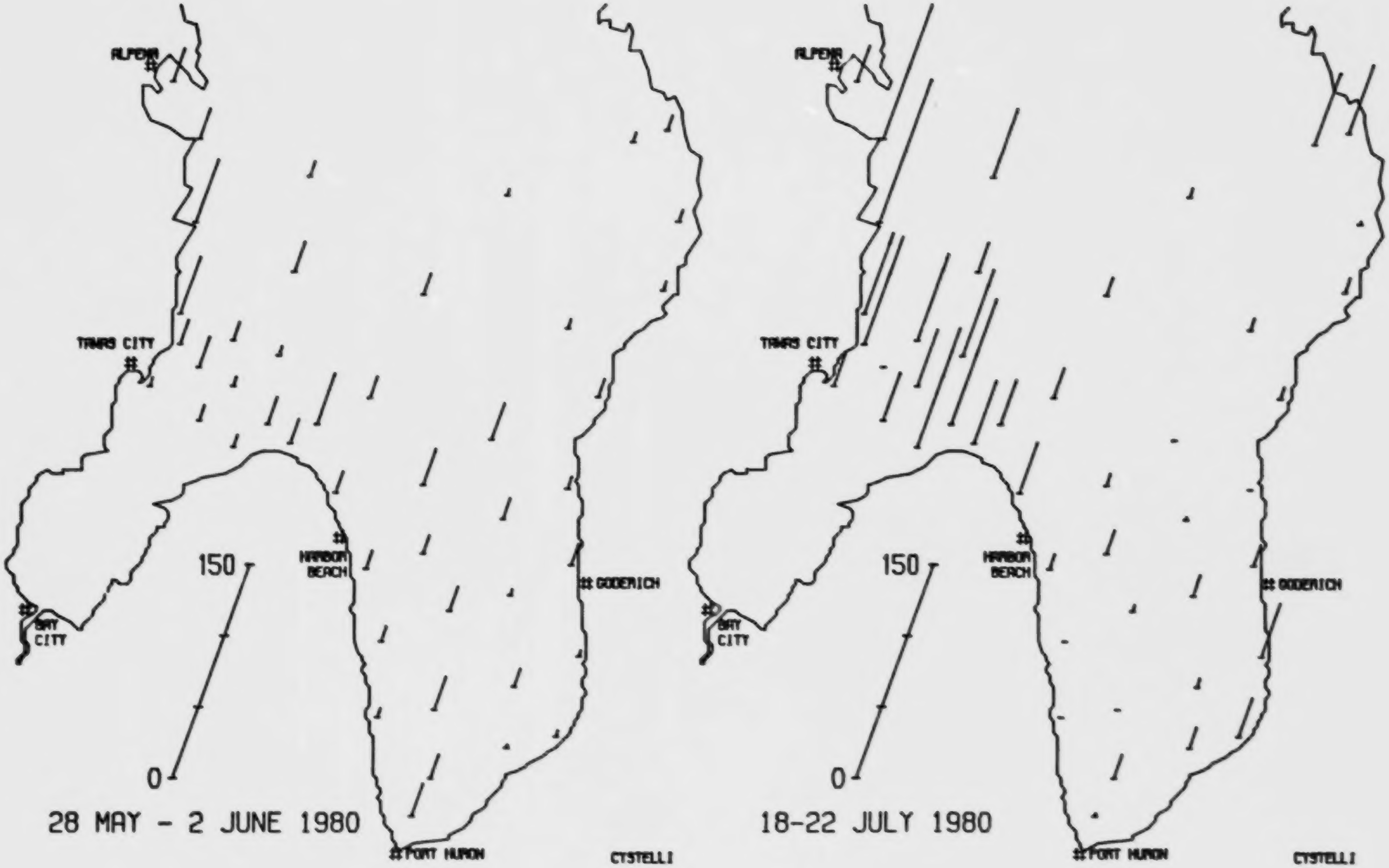
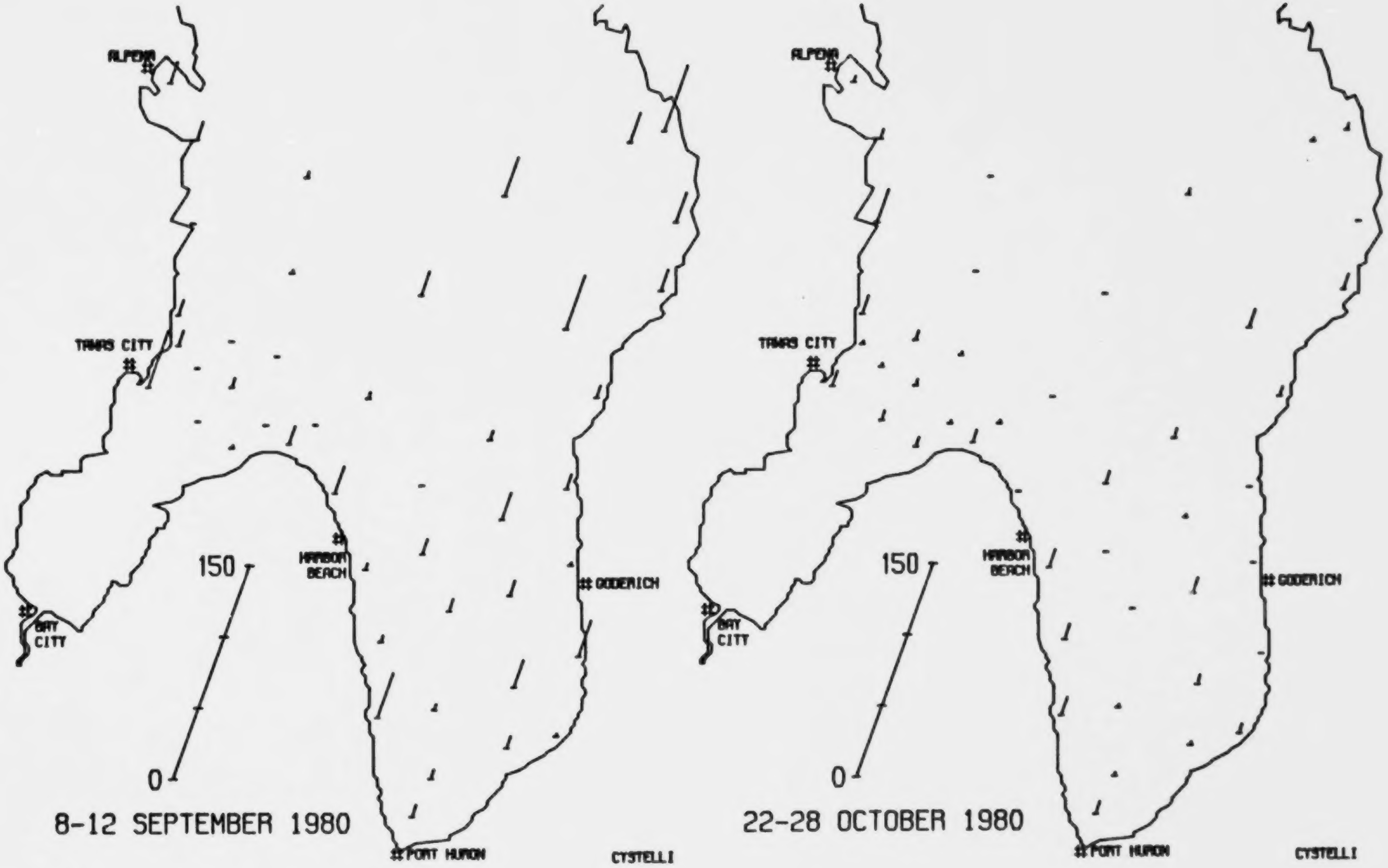

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
28 MAY - 2 JUNE 1980
CYSTELLI
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
18-22 JULY 1980
CYSTELLI

Figure 17. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
CYSTELLI
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
150
0
CYSTELLI

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 17. (continued)

highest cell numbers seen in nearshore areas. During June (fig. 18C) a wide but sporatic distrbution was noted in low abundances. Thunder Bay at Alpena showed the only population of this species at very low abundance which was virtually eliminated in July (fig. 18D). No occurrences were observed for the the remainder of the cruise season.

Fragilaria capucina

This species of Fragilaria is associated with enriched areas and may become abundant inside the spring thermal bar (Davis et al. 1980). In April (fig. 19A) it occurred in Saginaw Bay and at a few U.S. nearshore stations in the southern basin. During May (fig. 19B) slightly increased abundance was seen in outer Saginaw Bay with several occurrences along the Canadian shore in the southern basin. Slightly reduced abundances were noted in June (fig. 19C) where it was restricted to Saginaw Bay and the nearshore zone in the southern basin. A single station in Saginaw Bay at Tawas City contained this species during September (fig. 19D). In October (fig. 19E) it was observed in highest abundance for the year in Saginaw Bay and along the U.S. coastal region in both basins.

Fragilaria crotonensis

This species is cosmopolitan exhibitng a wide range of tolerances. It is probably the most reported planktonic species of the genus. In April (fig. 20A) largest abundances were seen along the entire U.S. shoreline and in and just outside of Saginaw Bay. It reached its largest

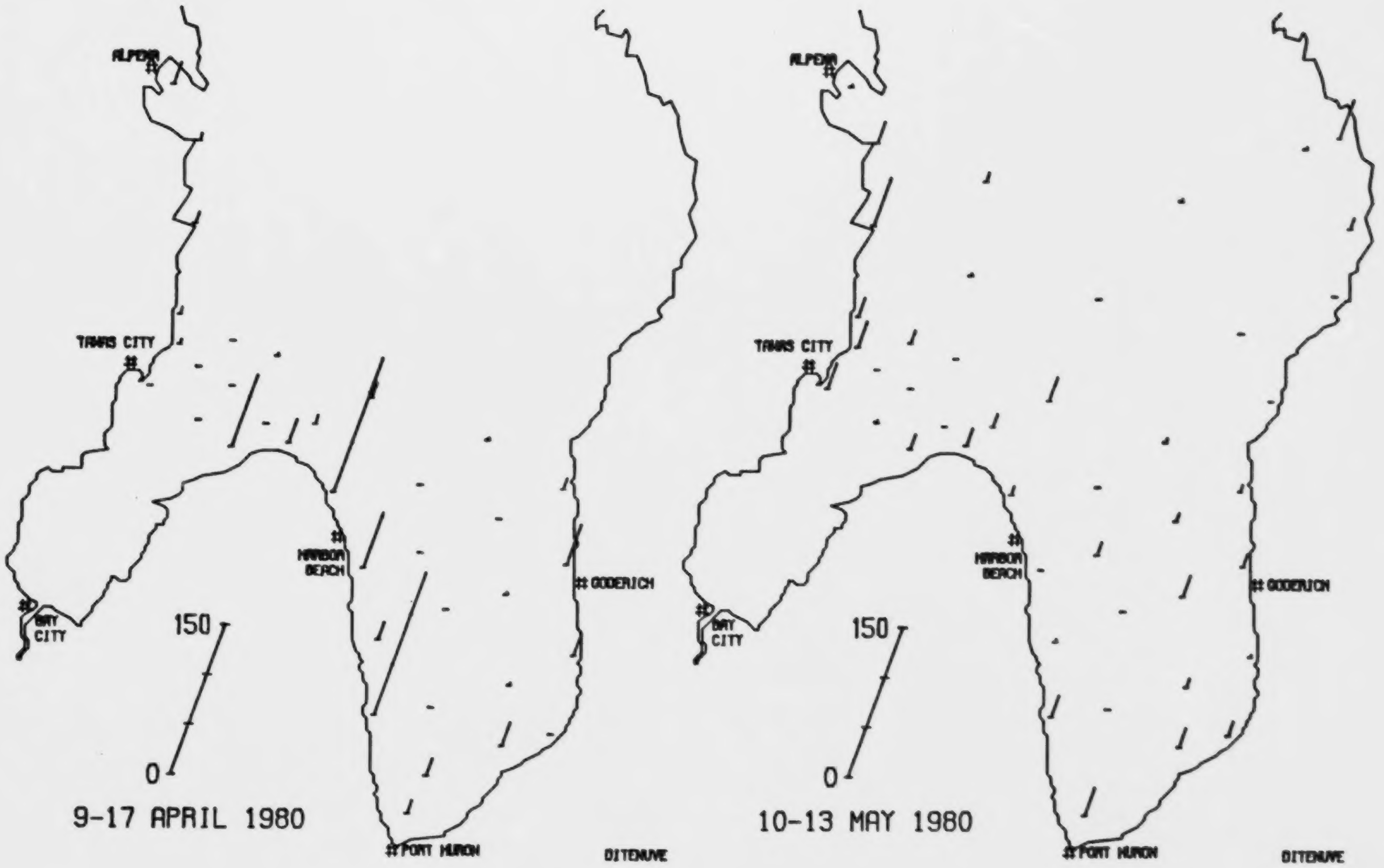

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DITENUVE
150
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DITENUVE
150
0
10-13 MAY 1980

Figure 18. Distribution of Diatoma tenue var. elongatum.

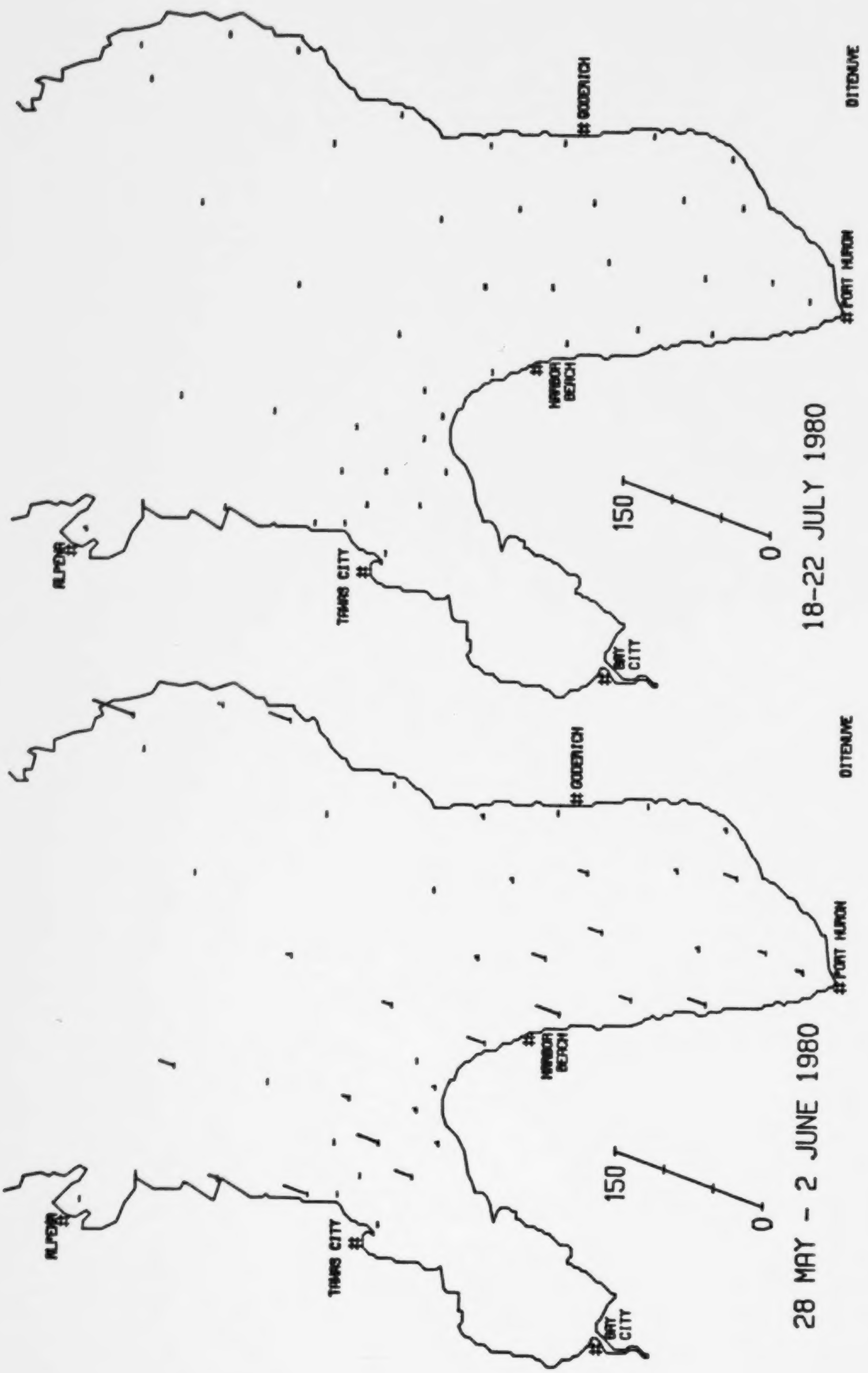

28 MAY - 2 JUNE 1980
18-22 JULY 1980
150
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
OITENUVE

Figure 18. (continued)

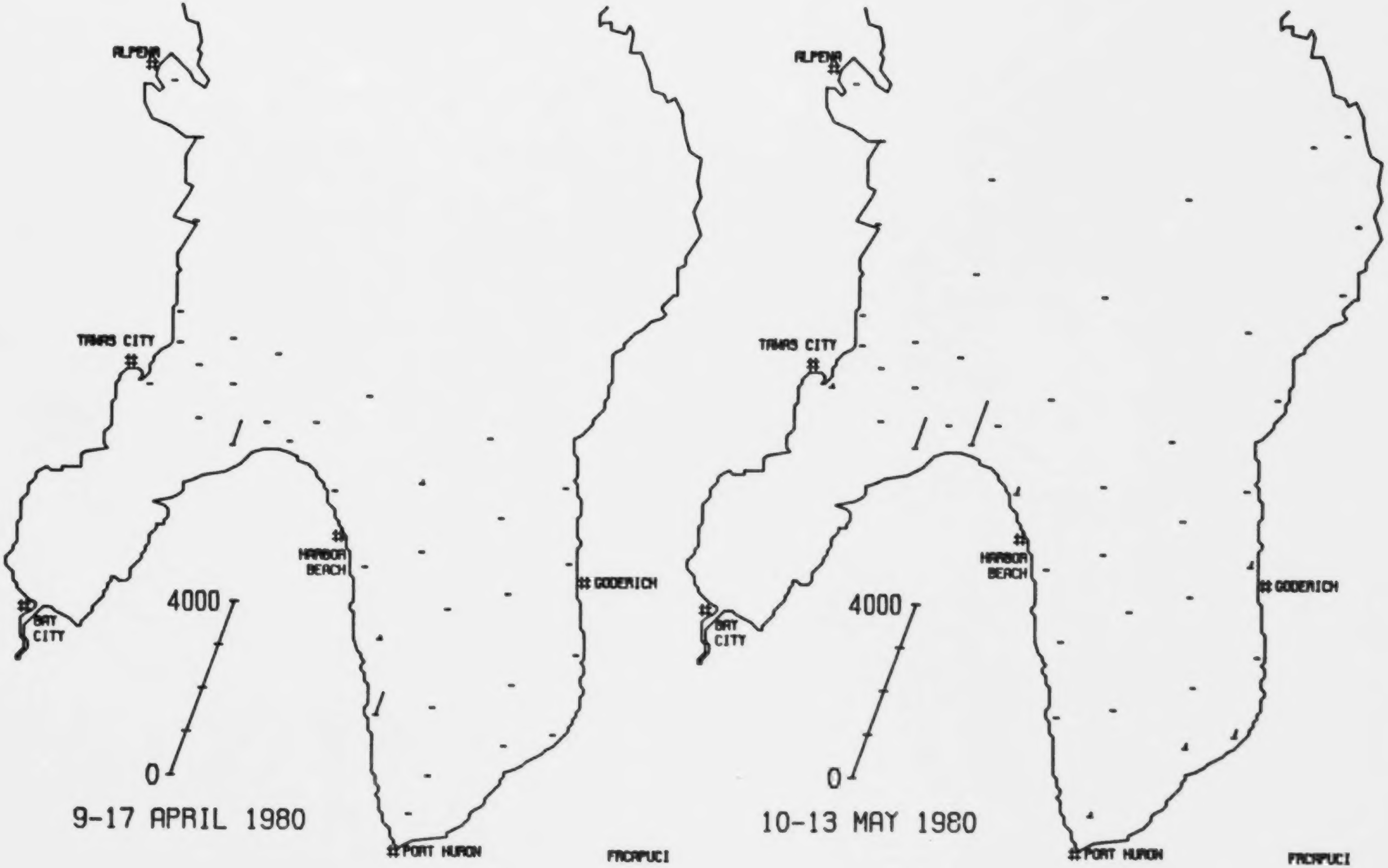
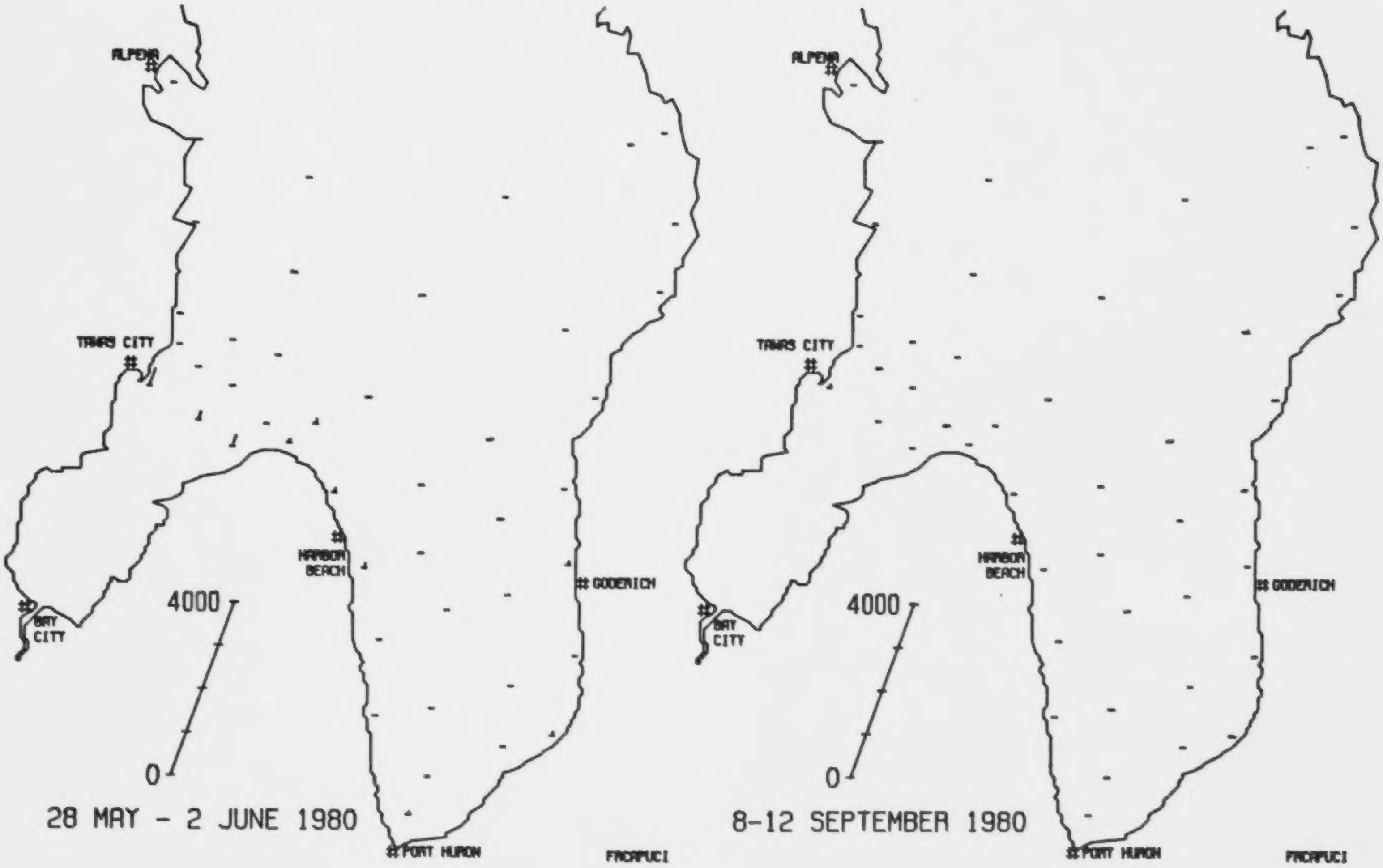

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
9-17 APRIL 1980
FRCAPUCI
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
10-13 MAY 1980
FRCAPUCI

Figure 19. Distribution of Fragilaria capucina.


ALPENA
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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FACAFUCI
4000
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FACAFUCI
4000
0

28 MAY - 2 JUNE 1980

8-12 SEPTEMBER 1980

Figure 19. (continued)

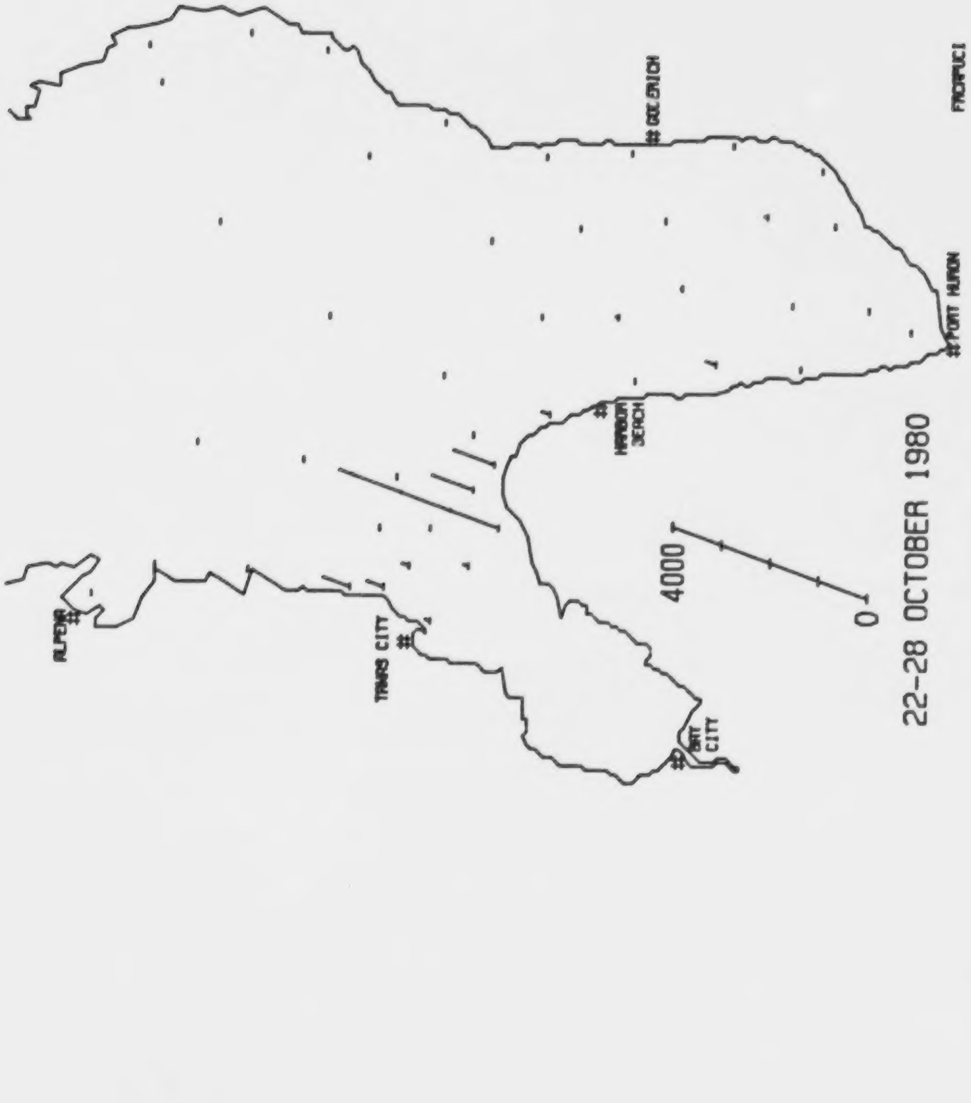

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
FROPUCI
4000
0
22-28 OCTOBER 1980

Figure 19. (continued)

single occurrence in the nearshore area south of Goderich (fig. 20B) in May but was widely distributed. During June (fig. 20C) it was present along the entire Canadian shoreline and in an erratic pattern elsewhere. Large abundances were observed between Alpena and Tawas City nearshore in July (fig. 20D). It also occurred along the Canadian coastline but was greatly reduced in offshore waters during this sampling period. In September (fig. 20E) abundances were low over the lake with most occurrences centered in the northwestern sector. October abundances were slightly higher with greatest abundances in the northwestern sector of the central basin but distribution was erratic (fig. 20F).

Fragilaria pinnata

This species of *Fragilaria* and its varieties are associated with littoral habitats usually growing in the periphyton or in benthic assemblages. Fairly large abundances were noted in the U.S. coastline and Saginaw Bay in April (fig. 21A). During May (fig. 21B) a large peak was observed nearshore between Alpena and Tawas City. During June through July (figs. 21C and 21D) cell numbers were greatly reduced . In September (fig. 21E) occurrences were noted in Saginaw Bay and south of the bay. During October (fig. 21F) large abundaces were seen just north of Tawas City, south of Saginaw Bay and a large peak at Port Huron.

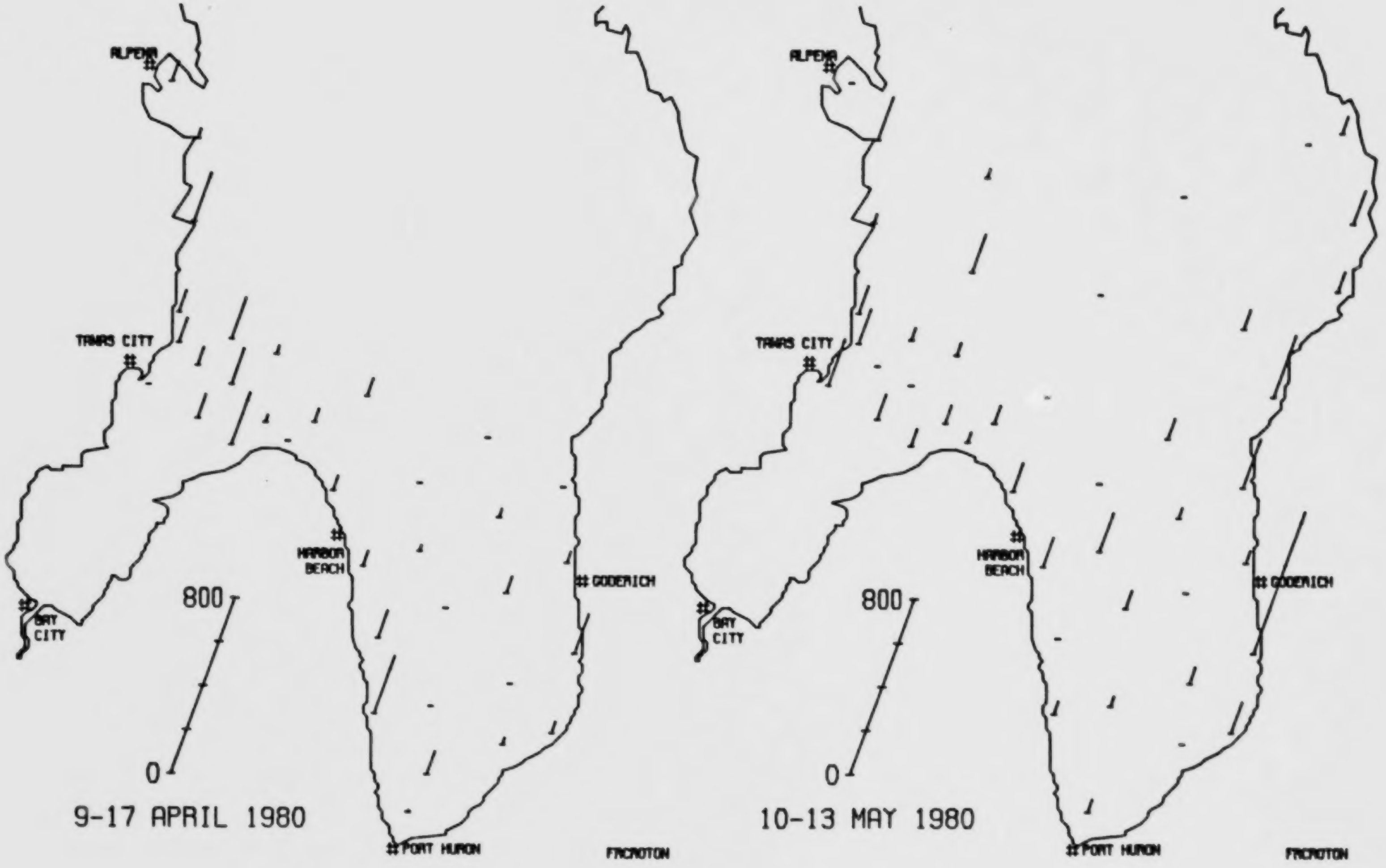

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
800
0
9-17 APRIL 1980
FRCROTON
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
800
0
10-13 MAY 1980
FRCROTON

Figure 20. Distribution of Fragilaria crotonensis.

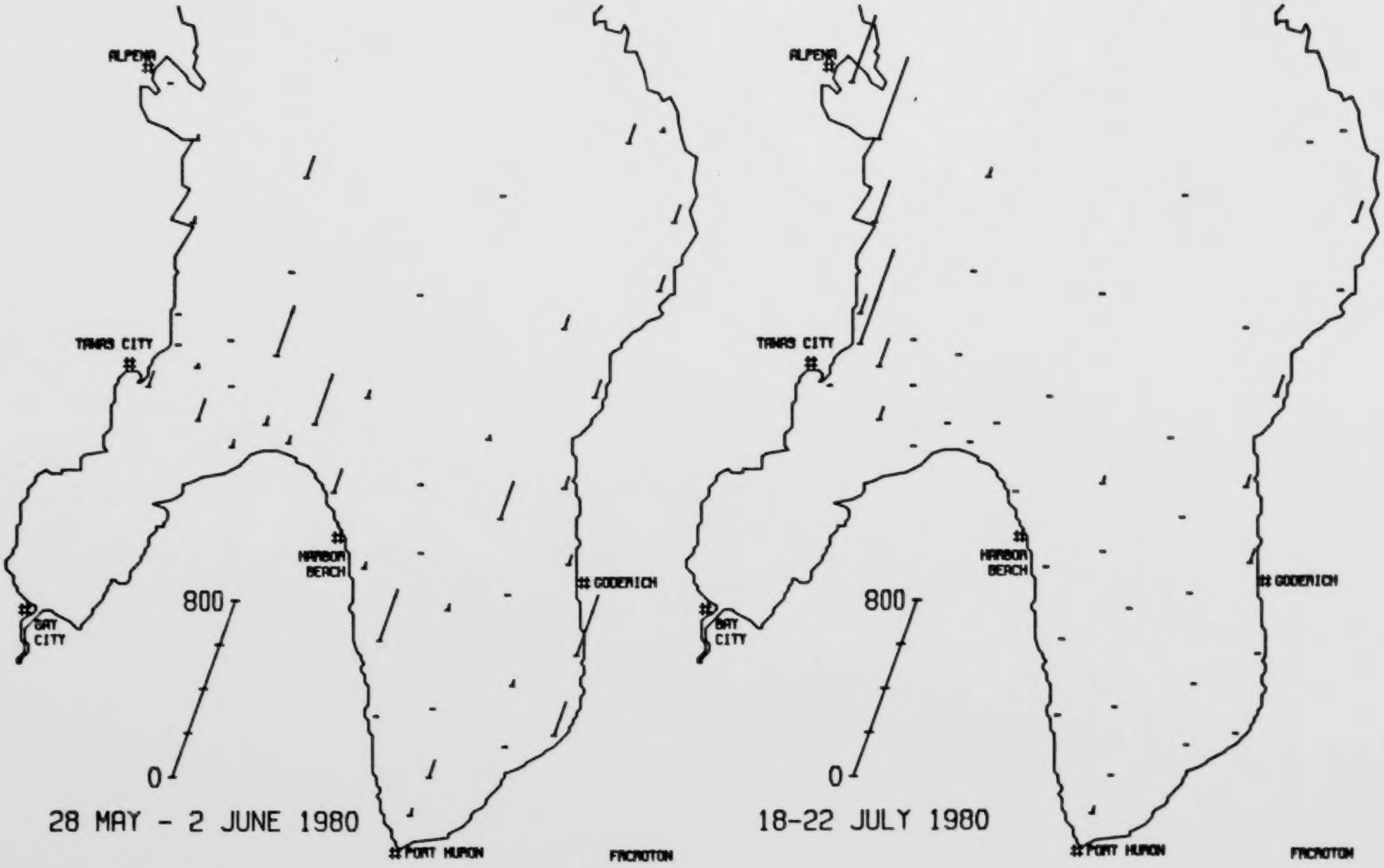
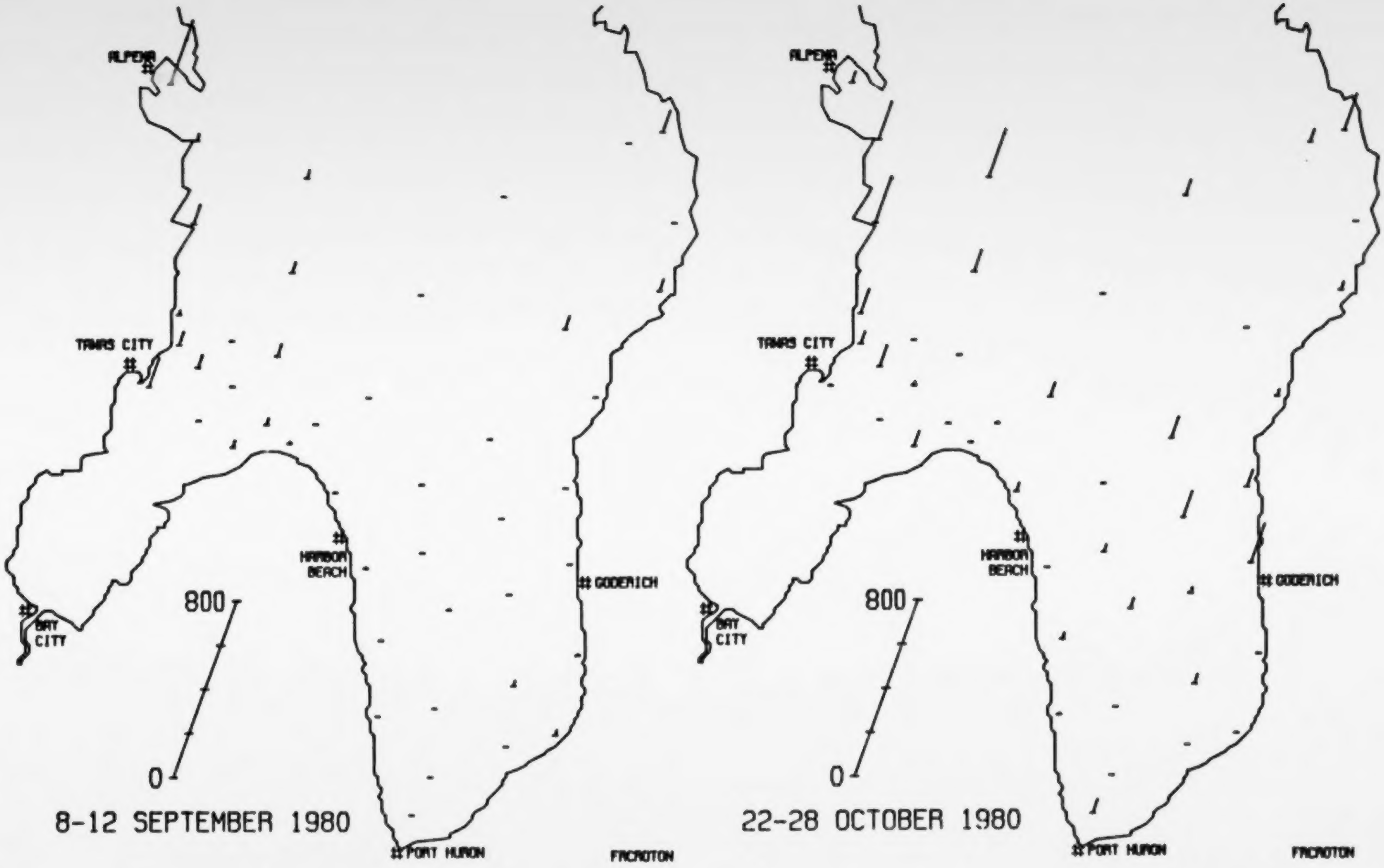

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
800
0
28 MAY - 2 JUNE 1980
FACROTON
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
800
0
18-22 JULY 1980
FACROTON

Figure 20. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FACROTON
800
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 20. (continued)

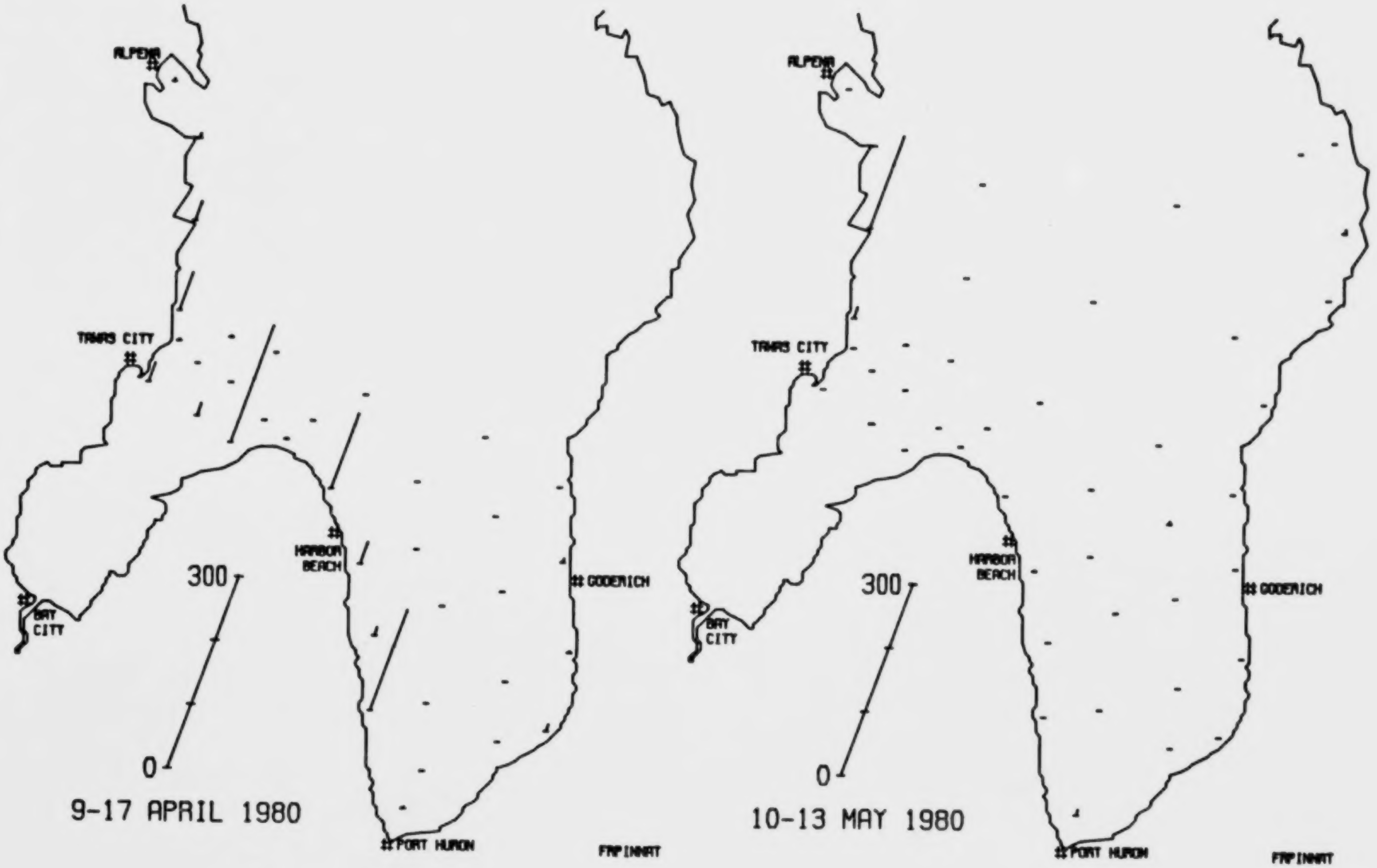

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
300
0
9-17 APRIL 1980
FRPINNAT
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
300
0
10-13 MAY 1980
FRPINNAT

Figure 21. Distribution of Fragilaria pinnata.

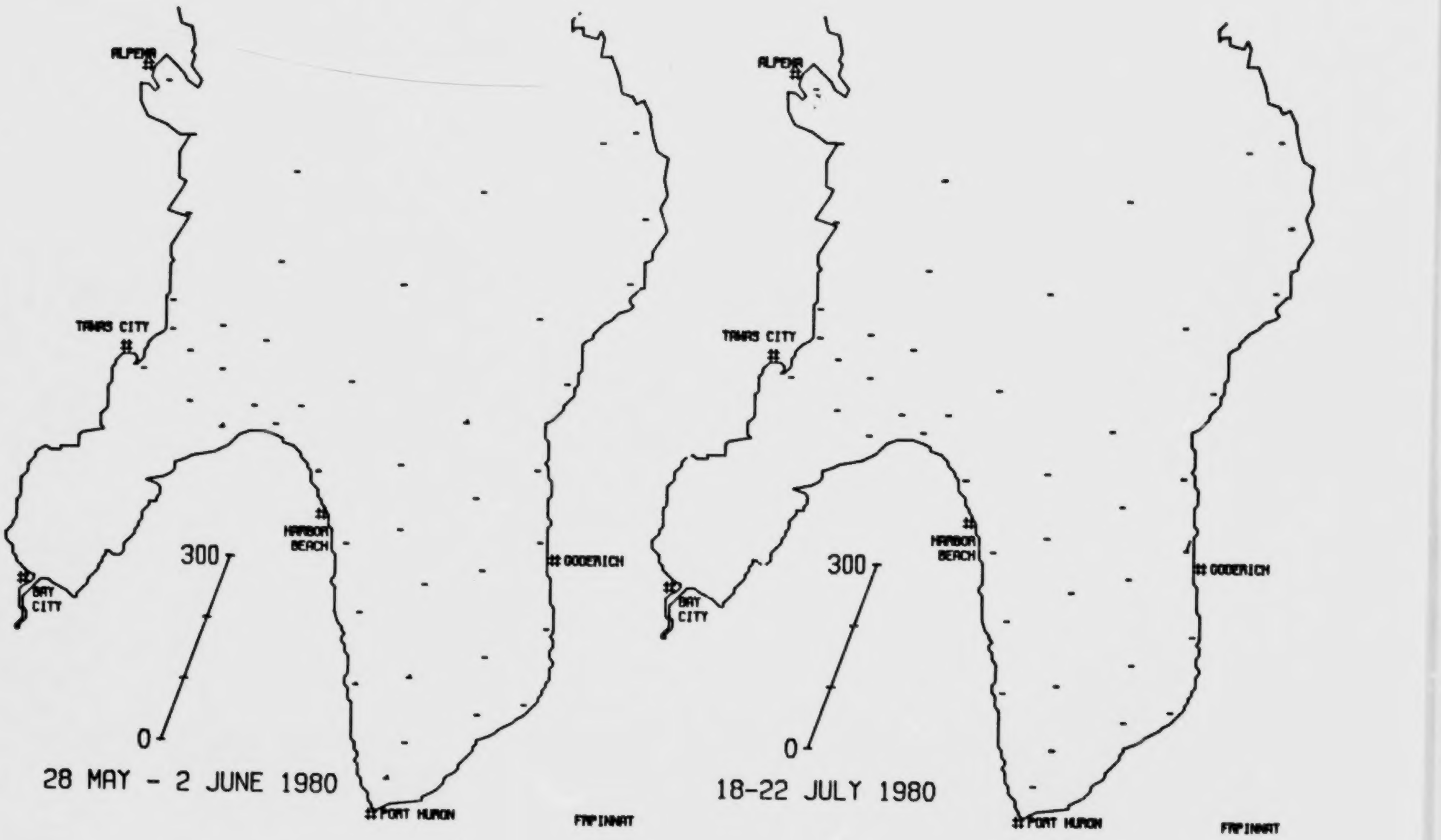
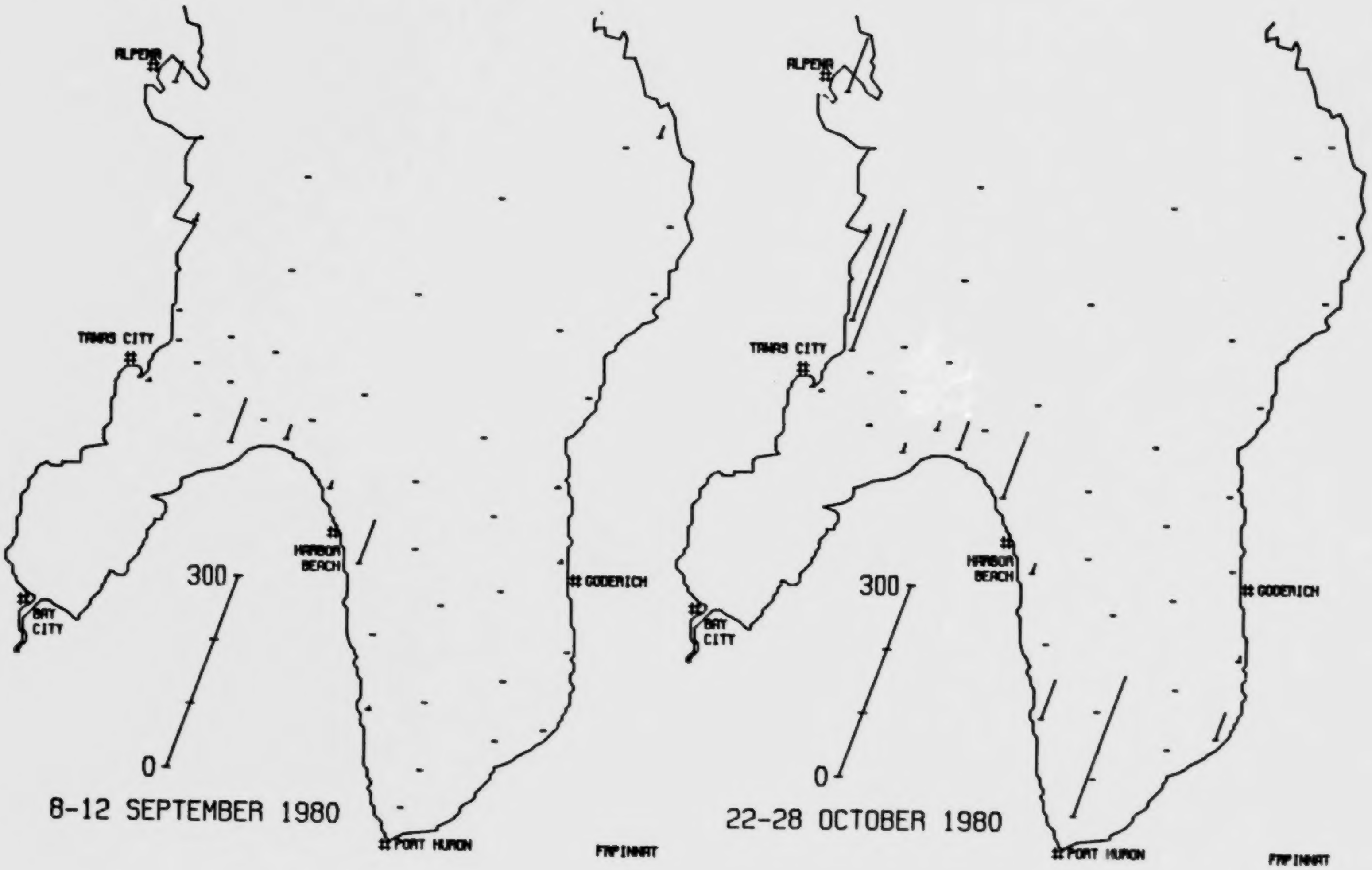

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
FRPINNAT
300
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
FRPINNAT
300
0
18-22 JULY 1980

Figure 21. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
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8-12 SEPTEMBER 1980
FRPINNAT
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
0
22-28 OCTOBER 1980
FRPINNAT

Figure 21. (continued)

Melosira granulata alpha-status

This is a morphologically coarse form of *Melosira granulata* which is found particularly in disturbed areas of the Great Lakes (Stoermer, *et al*. 1981). This species was a very minor assemblage component in southern Lake Huron. Populations were observed in outer Saginaw Bay and the nearshore zone below Saginaw Bay in April (fig. 22A). This taxon was not recorded through the remainder of the spring and summer until September (fig. 22B) where a single occurrence was observed nearshore north of Tawas City. During October (fig. 22C) two sites in outer Saginaw Bay and the interface had this species present.

Melosira islandica

M. islandica has been reported from all of the Great Lakes and is usually found in widest distribution and highest abundance in the spring (Stoermer *et al*. 1981). In April (fig. 23A) highest abundance was seen nearshore south of Goderich., High cell concentrations were centered in the southern basin with lesser abundances in Saginaw Bay interface waters and northward. During May (fig. 23B) highest abundances were recorded on the eastern side of the lake, although it was distributed throughout the survey area. During June (fig. 23C) population occurrence and abundance was centered along the long axis of the study area and on the Canadian shoreline. Reduced and very low abundances were observed for the remainder of the season (figs. 23D and 23E).

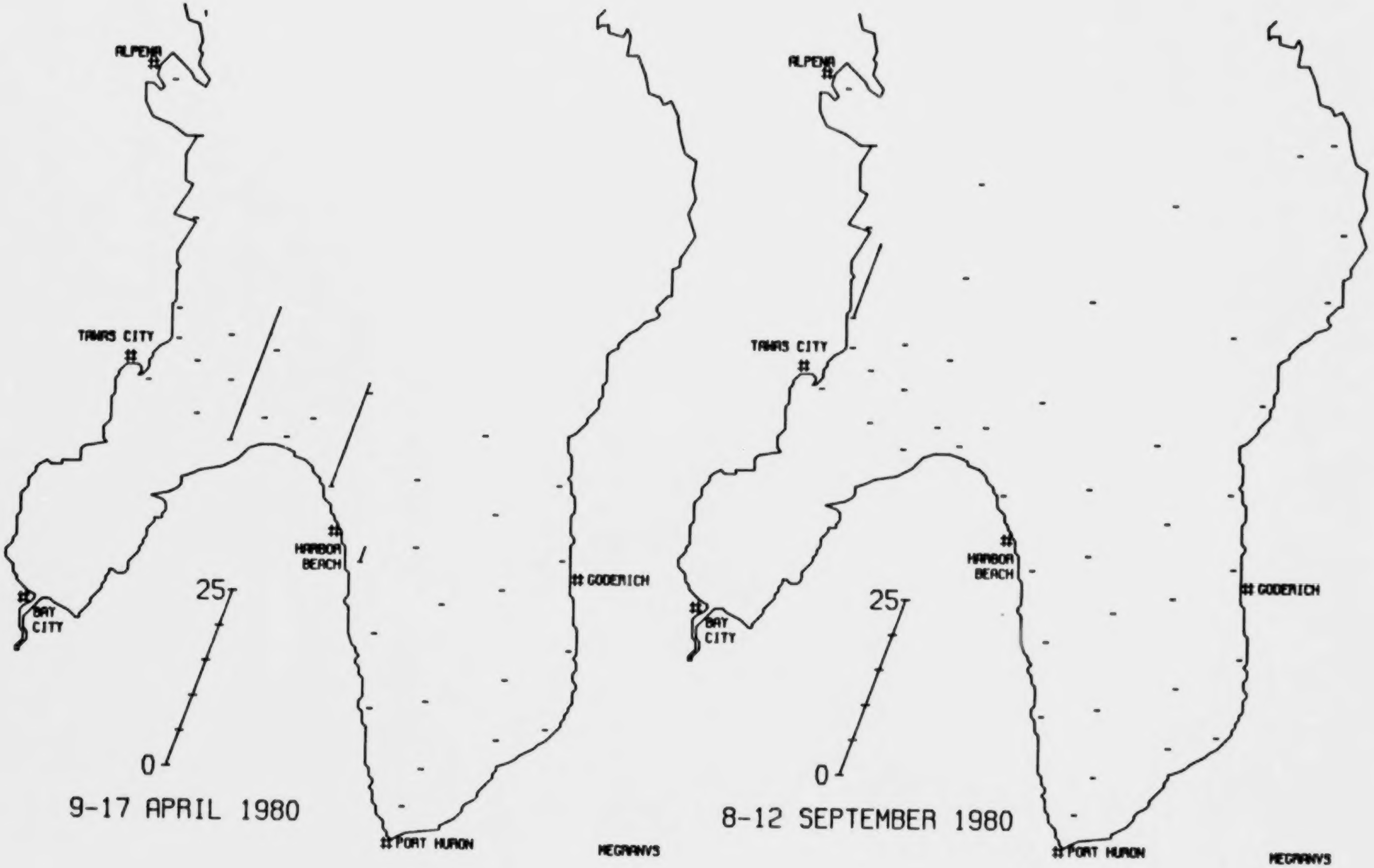

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
MEGRAMVS
25
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
MEGRAMVS
25
0
8-12 SEPTEMBER 1980

Figure 22. Distribution of Melosira granulata alpha-status.

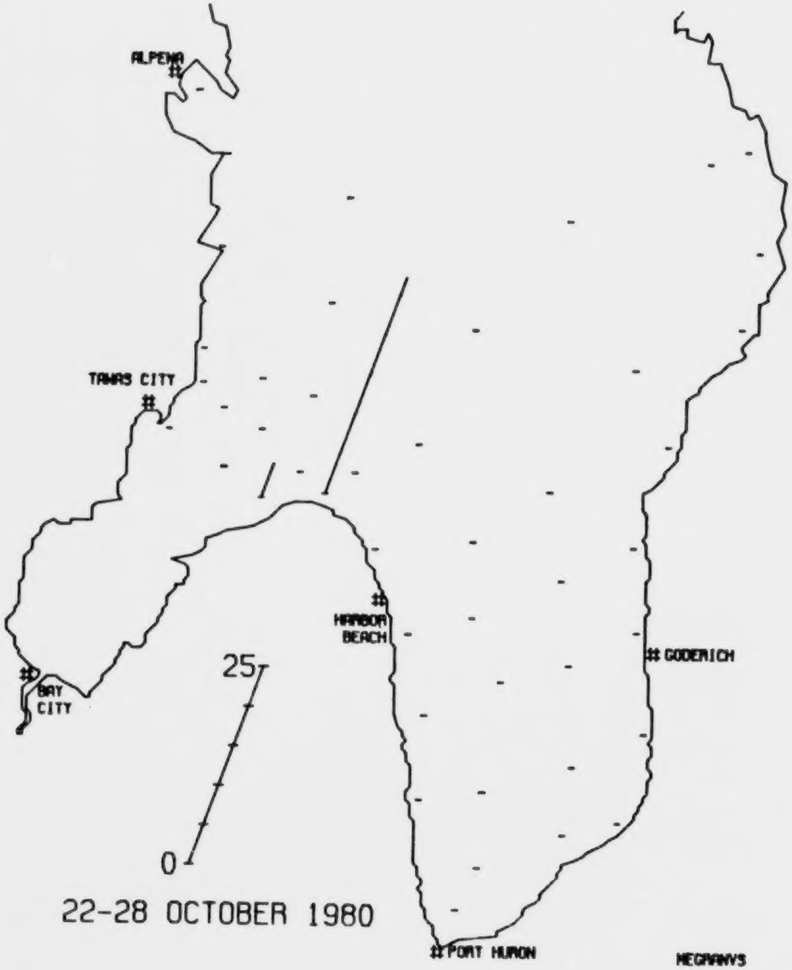

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
MEGRAWVS
25
0
22-28 OCTOBER 1980

Figure 22. (continued)

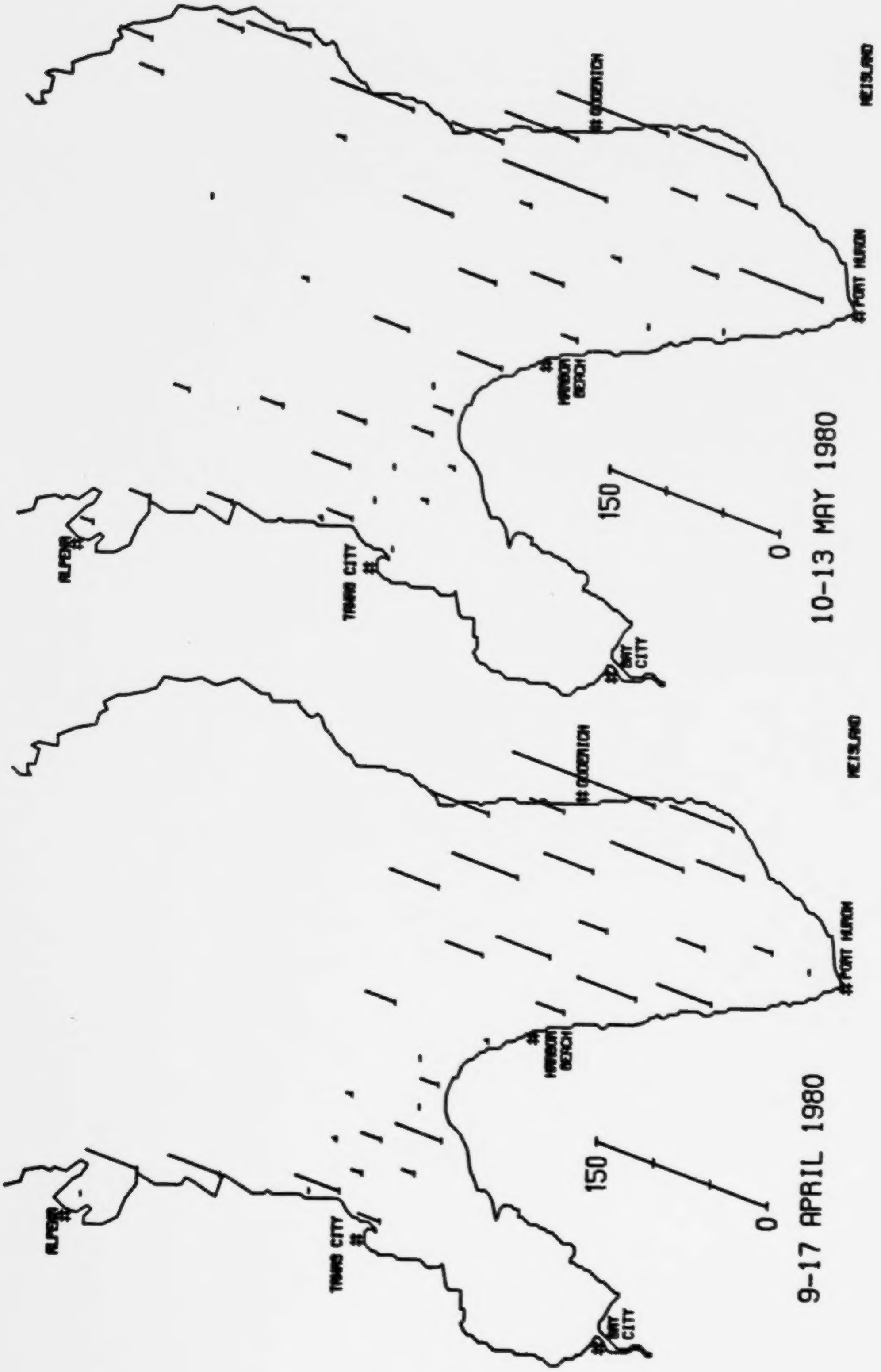
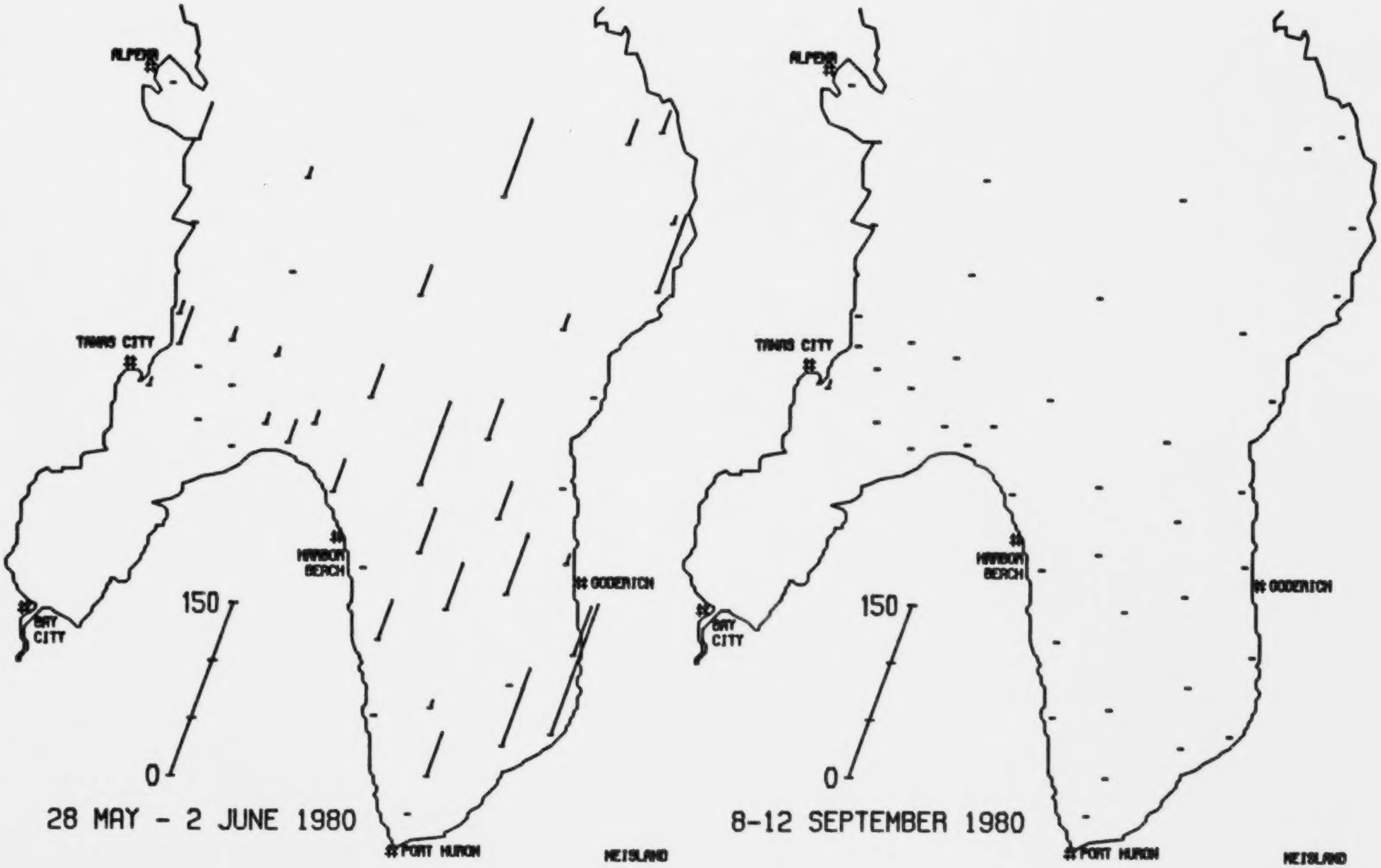

9-17 APRIL 1980
150
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
MEISLAND
10-13 MAY 1980
150
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
MEISLAND

Figure 23. Distribution of Melosira islandica.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
MEISLAND
150
0

28 MAY - 2 JUNE 1980

8-12 SEPTEMBER 1980

Figure 23. (continued)

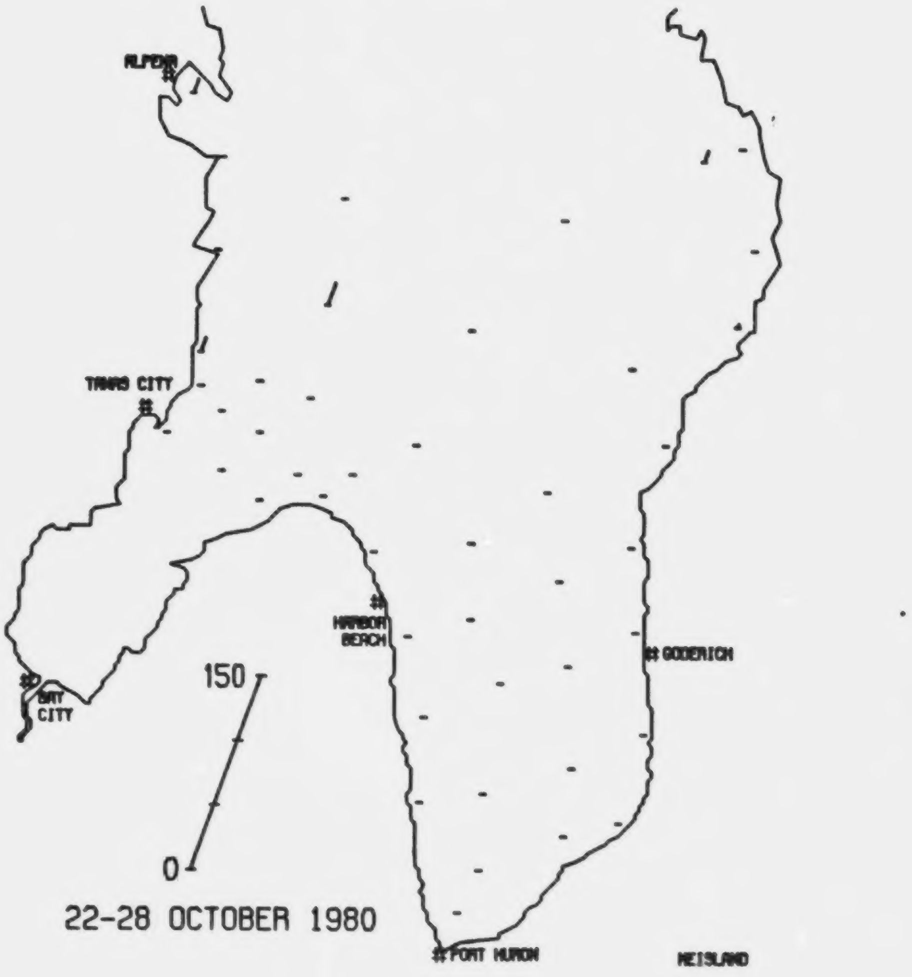

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
150
0
22-28 OCTOBER 1980
PORT HURON
FE ISLAND

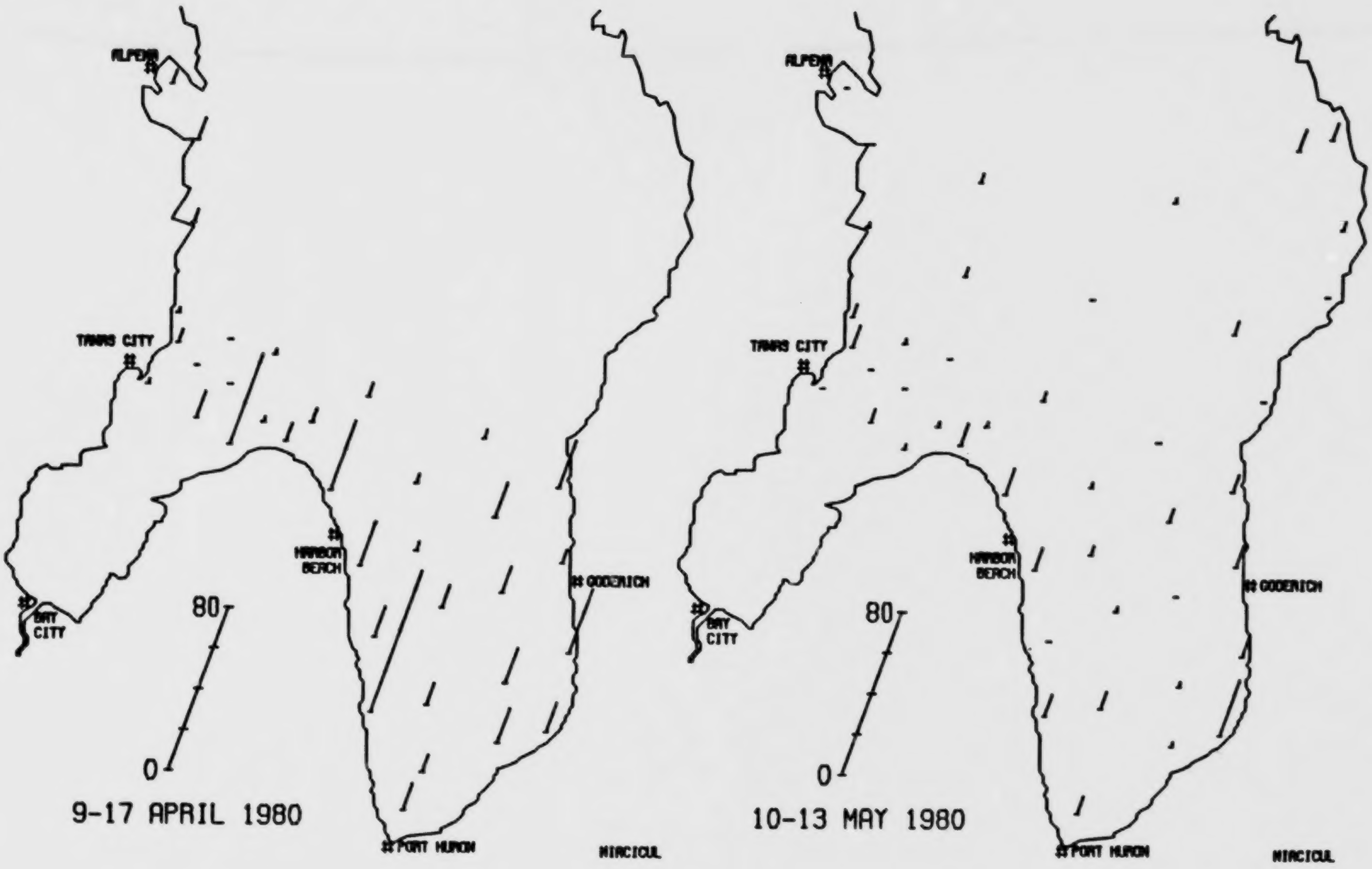
Figure 23. (continued)

Nitzschia acicularis

Unlike most species of this genus, N. acicularis may be seen in the euplankton, particularly in the spring months. During April (fig. 24A) it was observed at its highest abundance for the season with greatest abundance along the U.S. coastline in the southern basin. In May (fig. 24B) it was widely distributed but at comparatively reduced abundance. Highest abundance for this month was recorded in the southern basin nearshore zone. During June (fig. 24C) highest abundances were observed in the offshore waters of the southern basin. In July and September (figs. 24D and 24E) very few occurrences were observed at low abundance. In October (fig. 24F) low abundances were observed along the entire U.S. coastline and Saginaw Bay area.

Nitzschia dissipata

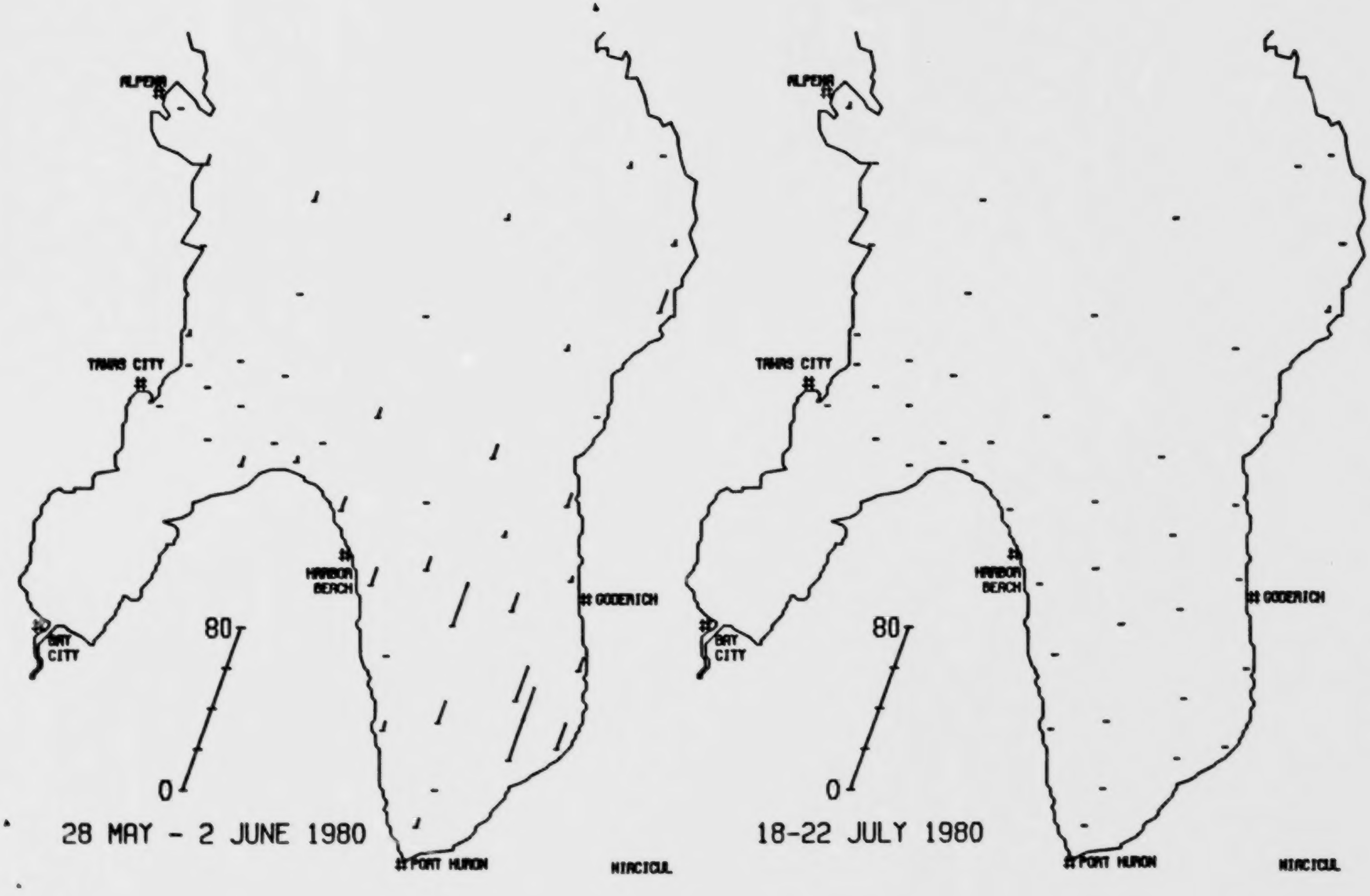
This taxon is commonly observed in the littoral zone of the Great Lakes but does occur, as seen in this study, in offshore waters. In April (fig. 25A) it occurred over a wide range of the study area with greatest abundances in the nearshore zones. In May (fig. 25B) it showed comparatively fewer occurences and was most abundant in the offshore waters, especially in the central basin. In June (fig. 25C) it was more abundant in the southern basin but had an erratic distribution. During July through October (figs. 25D and 25E) it occurred at only a few stations however in October it occurred at its single largest abundance recorded, north of Saginaw Bay.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIACICUL
80
0

9-17 APRIL 1980

10-13 MAY 1980

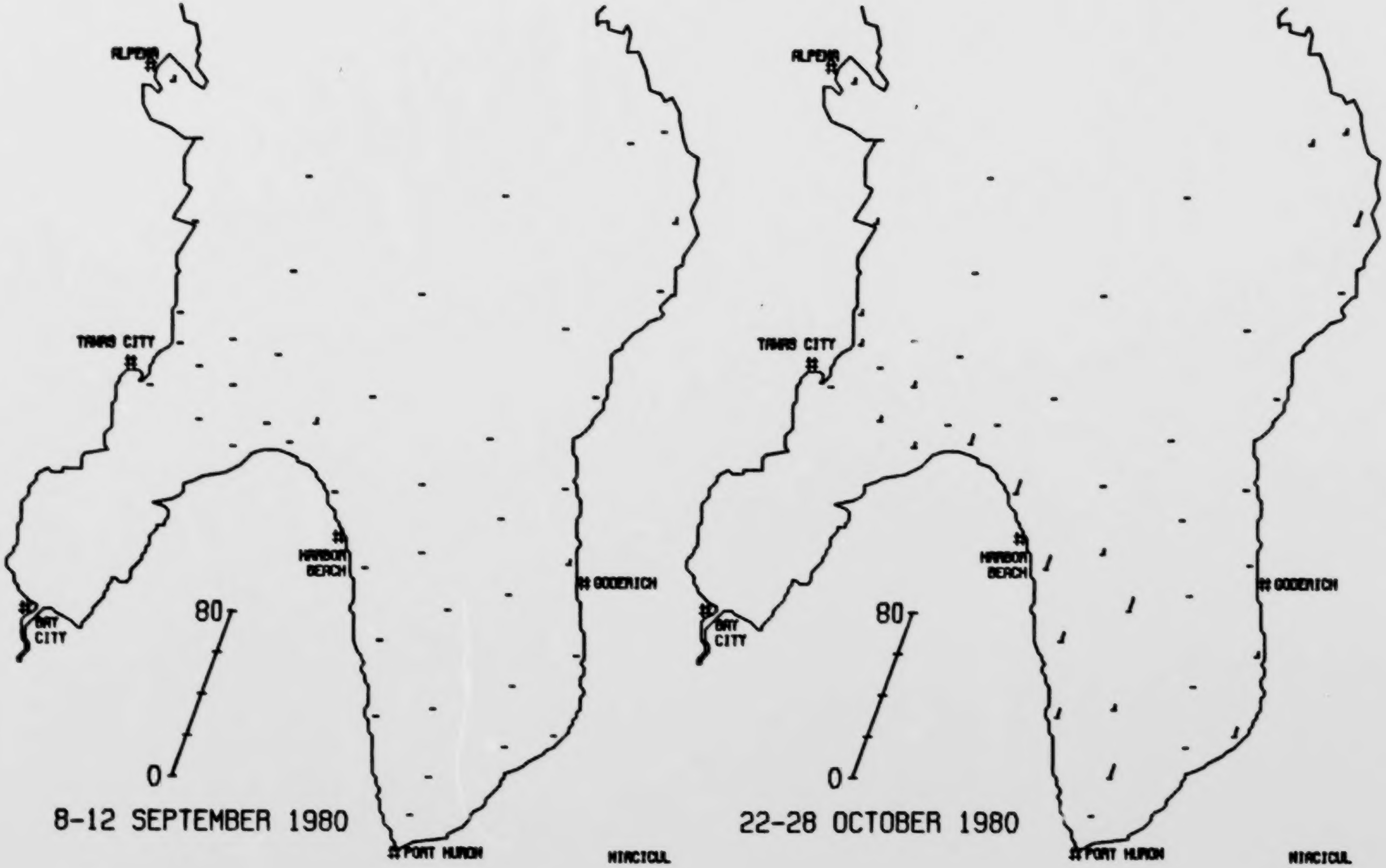
Figure 24. Distribution of Nitzschia acicularis.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
80
0
NIRCICUL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
80
0
NIRCICUL

28 MAY - 2 JUNE 1980

18-22 JULY 1980

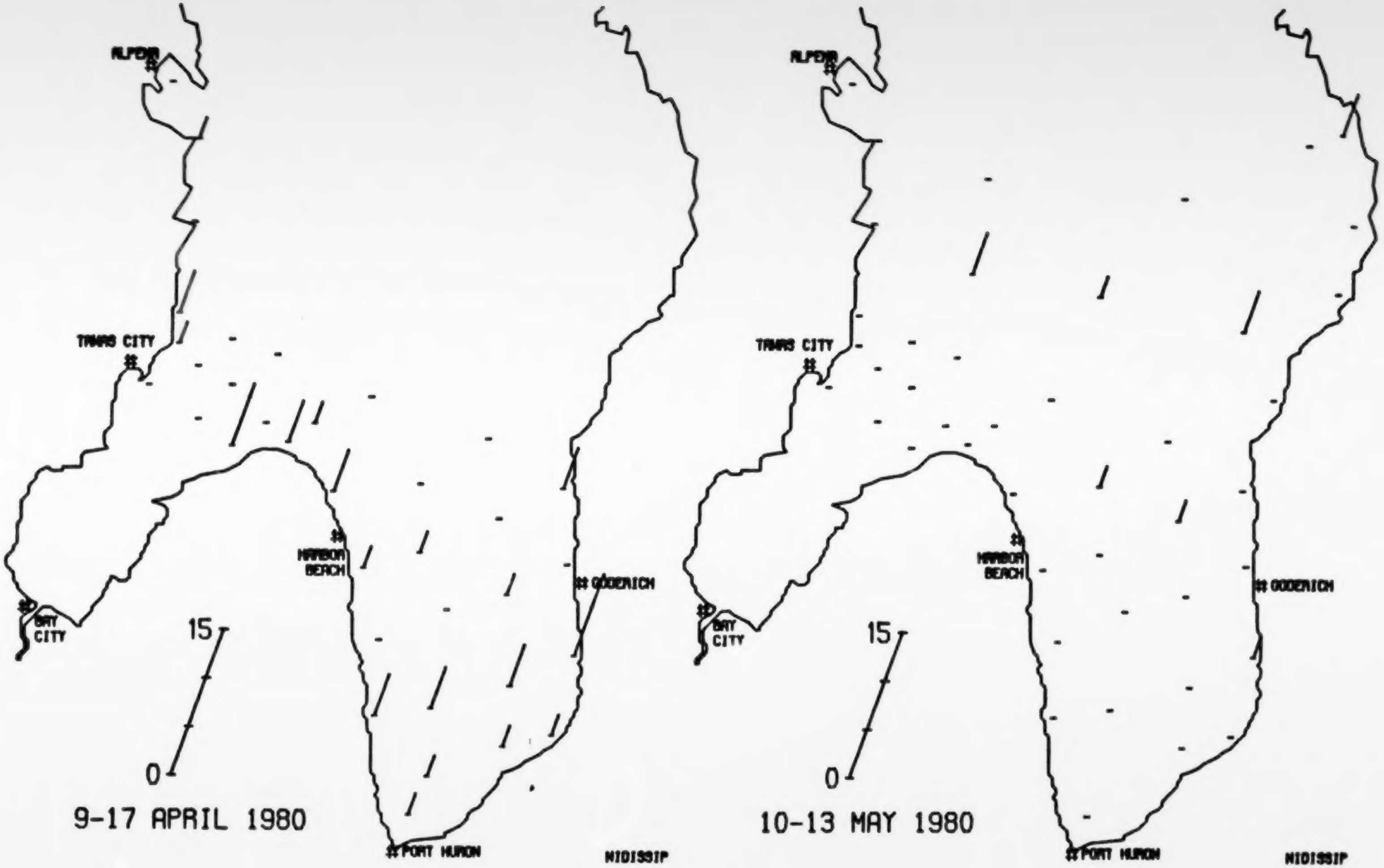
Figure 24. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIACICUL
80
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 24. (continued)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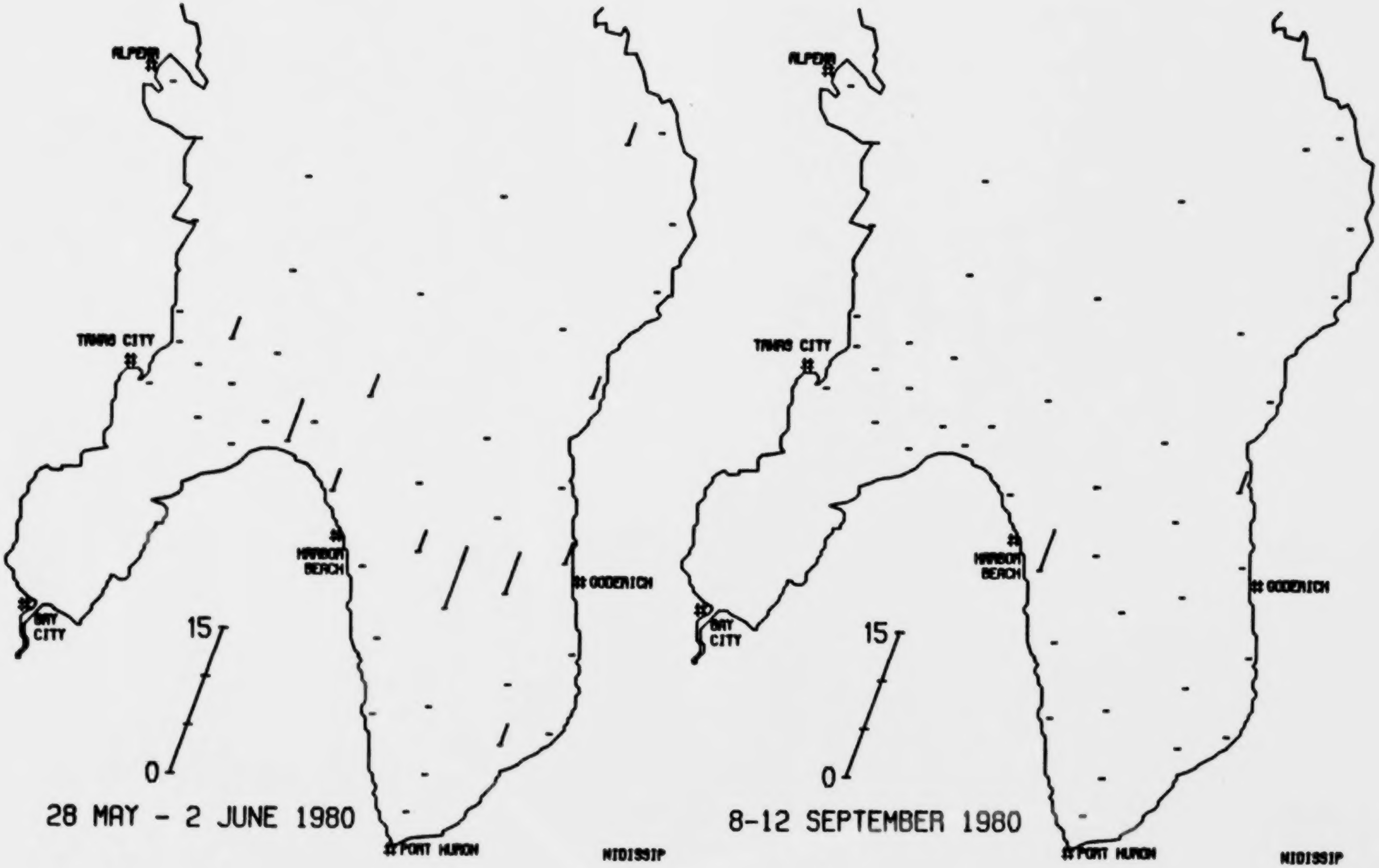
GODERICH
PORT HURON
NIDISSIP
15
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIDISSIP
15
0

9-17 APRIL 1980

10-13 MAY 1980

Figure 25. Distribution of Nitzschia dissipata.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TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIDISSIP
15
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIDISSIP
15
0
8-12 SEPTEMBER 1980

Figure 25. (continued)

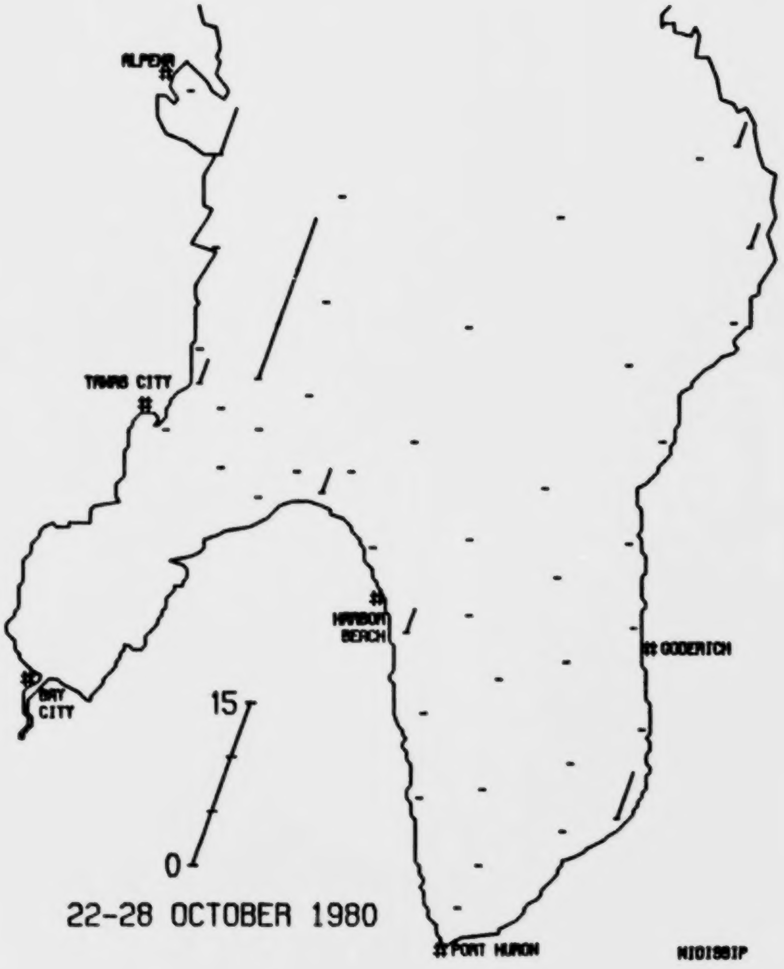

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
NIOISSIP
15
0
22-28 OCTOBER 1980

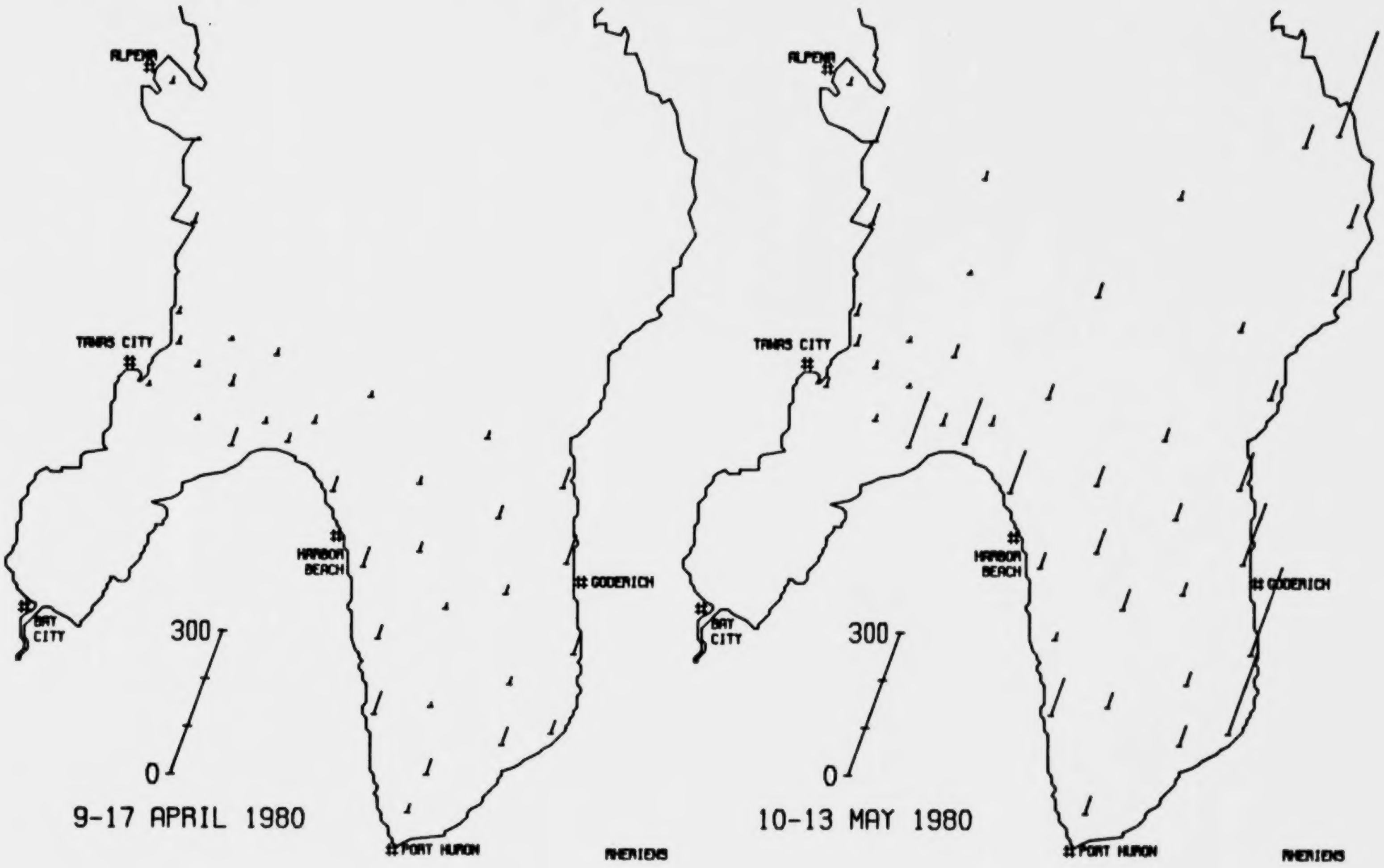
Figure 25. (continued)

Rhizosolenia eriensis

This lightly silicfied, delicate diatom species is commonly reported from the offshore waters during the spring in the upper Great Lakes, but it may be influenced by the thermal bar. It was originally described from tap water samples from Lake Erie (Smith 1878). During April (fig. 26A) it was uniformly distributed over the study area in low abundances. Increased standing crops were observed in May (fig. 26B) with highest abundances in the Canadian nearshore zone. During June (fig. 26C) it occurred over the entire study area with elevated abundances again along the Canadian coastline. Decreased occurrences were seen in July (fig. 26D) with populations being restricted to the central basin. Few occurrences were recorded for September (fig. 26E) with no apparent distribution trends. During October (fig. 26F) very low cell numbers were seen over most areas of the lake with highest values recorded south of Alpena.

Rhizosolenia gracilis

As the other member of this genus just discussed, R. gracilis appears in greatest abundance in the spring, however it may respond more than the other species to slightly enriched conditions (Nicholls et al. 1977). It was also originally described from Lake Erie by Smith (1882). Widest occurrence of this taxon was observed in April (fig. 27A) with largest values being recorded for the nearshore zones around the southern basin. In May


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
0
RHERIENS
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
0
RHERIENS

9-17 APRIL 1980

10-13 MAY 1980

Figure 26. Distribution of Rhizosolenia eriensis.

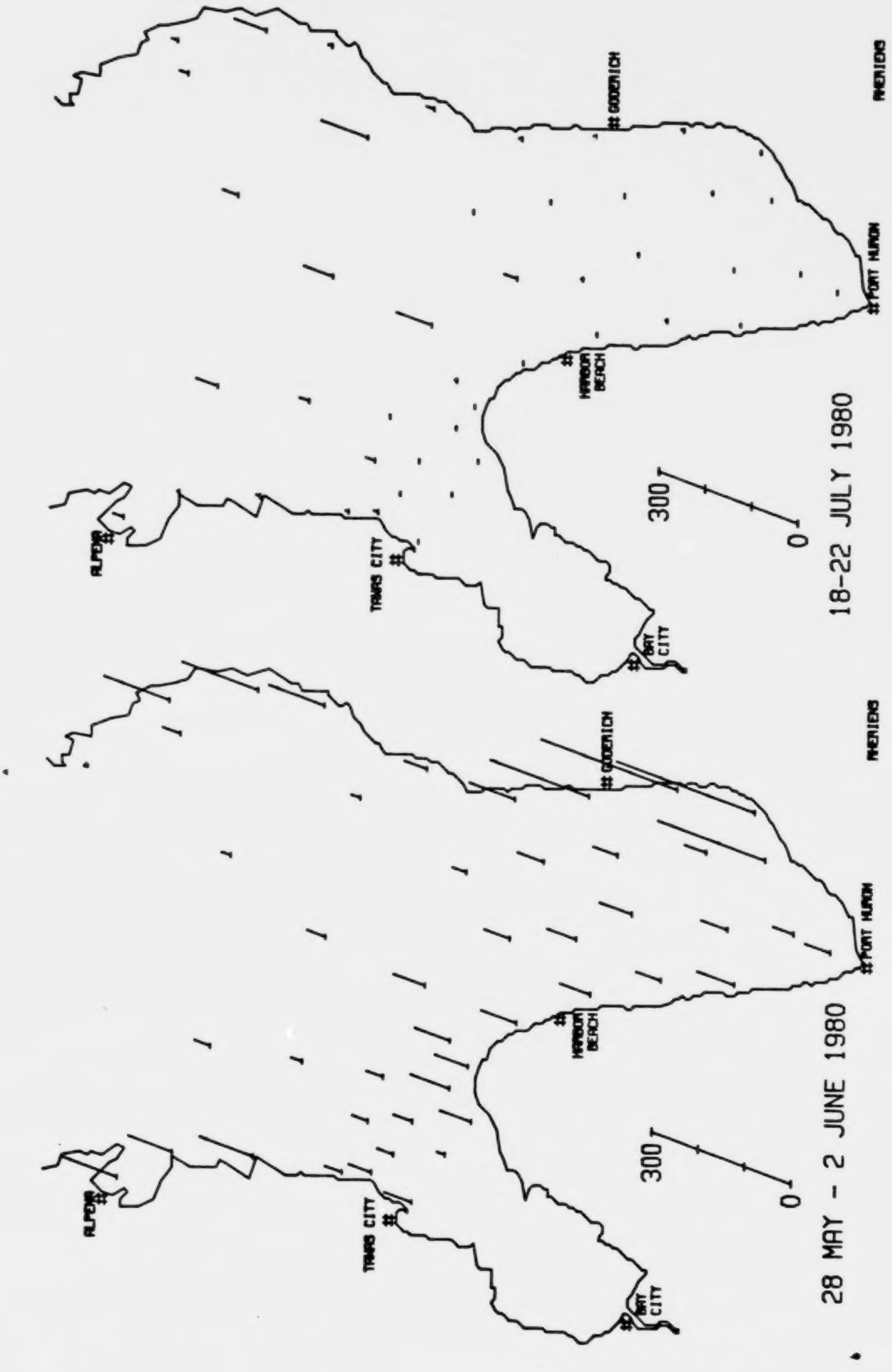

ALPENA
TRAVS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
AMERIENS
300
0
28 MAY - 2 JUNE 1980
ALPENA
TRAVS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
AMERIENS
300
0
18-22 JULY 1980

Figure 26. (continued)

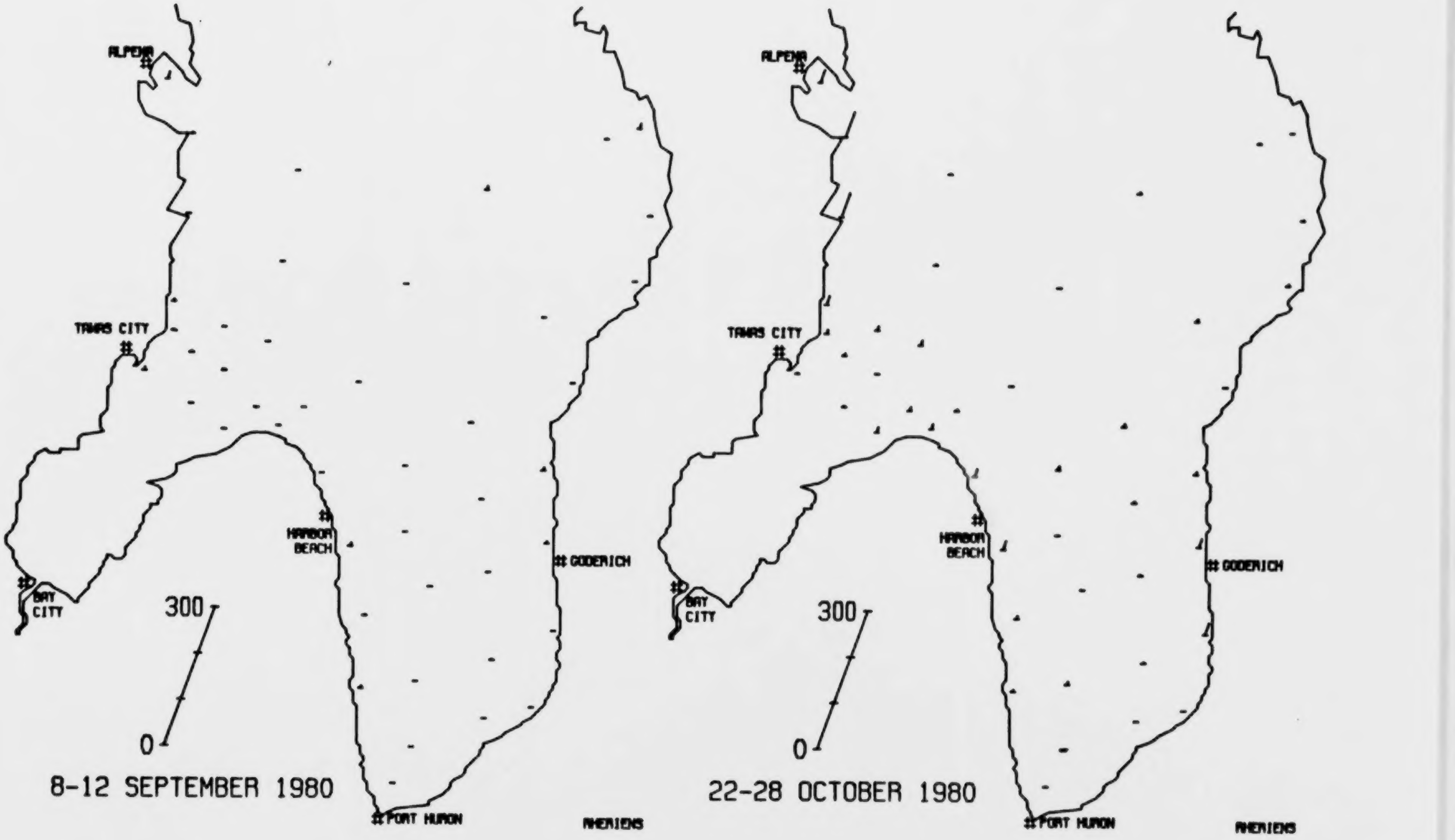

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
AMERIENS
300
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
AMERIENS
300
0
22-28 OCTOBER 1980

Figure 26. (continued)

(fig. 27B) its distribution was reduced but reached its highest single abundance nearshore, south of Goderich. Small populations were also observed nearshore between Alpena and Tawas City. Few occurences at low abundances were observed in June and October (figs. 27C and 27D).

Stephanodiscus alpinus

In the Great Lakes, this species reaches its greatest abundance during the spring months. This species had it greatest number of occurrences in April (fig. 28A). It was erratically distributed through the southern basin. Its single greatest abundance for the year occurred in the nearshore zone between Harbor Beach and Port Huron. In May (fig. 28B) it was observed in outer Saginaw Bay and in the Canadian nearshore zone in the southern basin. In June (fig.28C) it was restricted to the U.S. coastline and outer Saginaw Bay in low abundances. During July and September (figs.28D and 28E) a few occurrences were recorded in the nearshore zones of the central basin. In October (fig. 28F) very low abundances were seen near outer Saginaw Bay, Tawas City and the lower southern basin.

Stephaodiscus binderanus

This species of Stephanodiscus is a colonial form which is associated with degraded water quality. In the 1950's it was considered a nuisance species since it clogged filters at water intake facilities (Vaughn 1961). In April (fig. 29A) it was observed in low abundance in outer Saginaw Bay and on the southern U.S. shoreline. In May

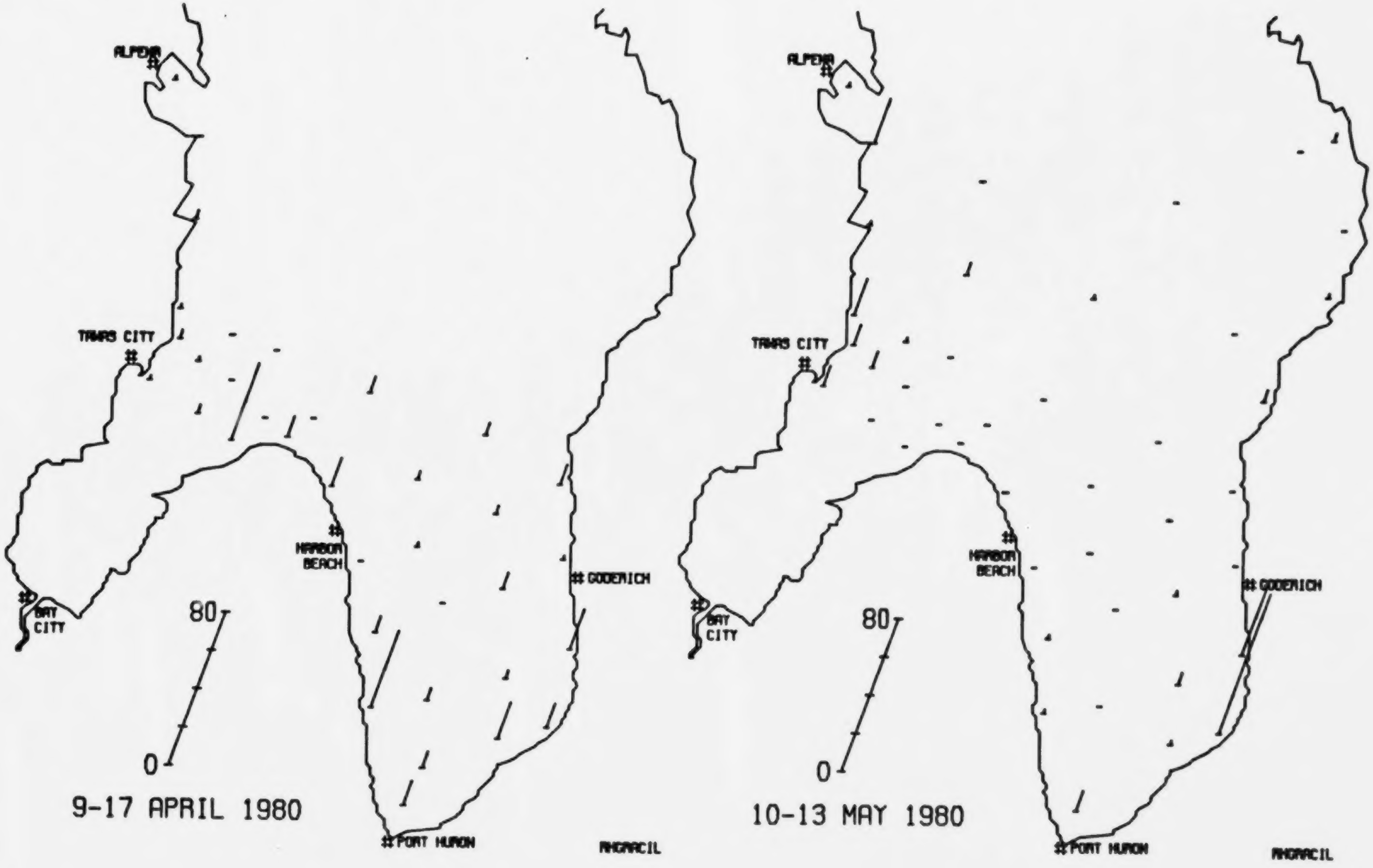
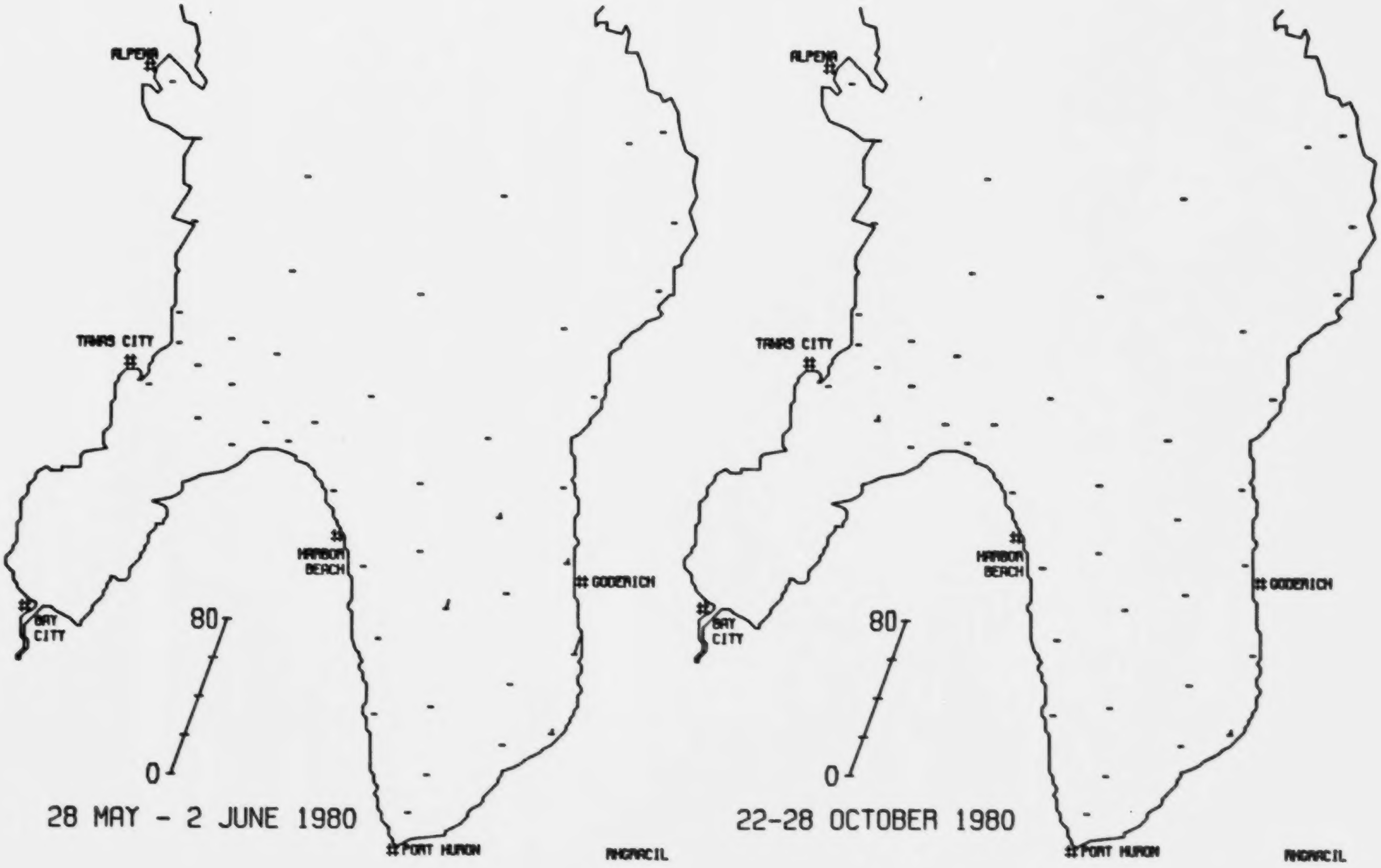

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
80
0
9-17 APRIL 1980
RHGRACIL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
80
0
10-13 MAY 1980
RHGRACIL

Figure 27. Distribution of Rhizosolenia gracilis.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
80
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
80
0

28 MAY - 2 JUNE 1980

22-28 OCTOBER 1980

Figure 27. (continued)

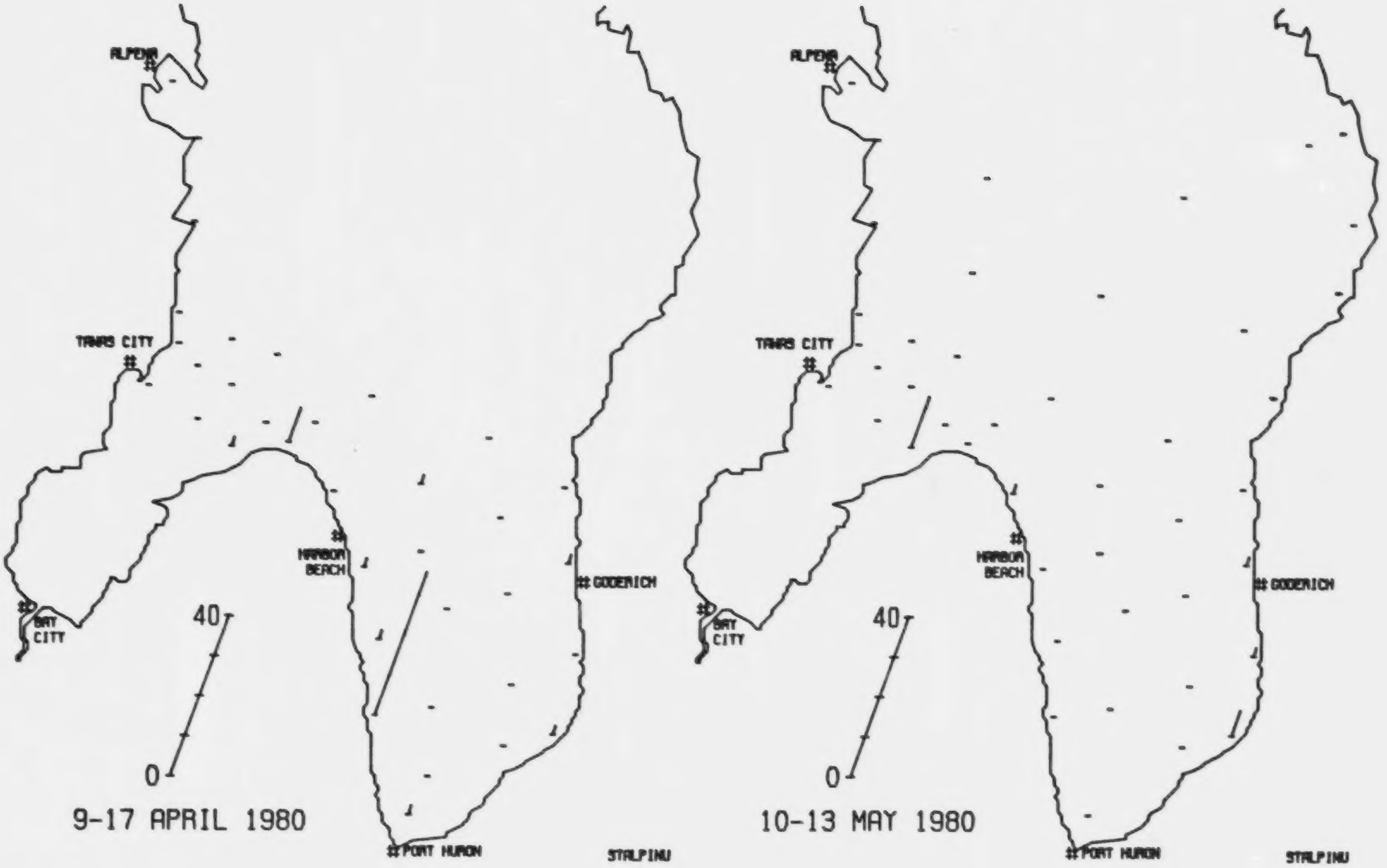

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0
10-13 MAY 1980

Figure 28. Distribution of Stephanodiscus alpinus.

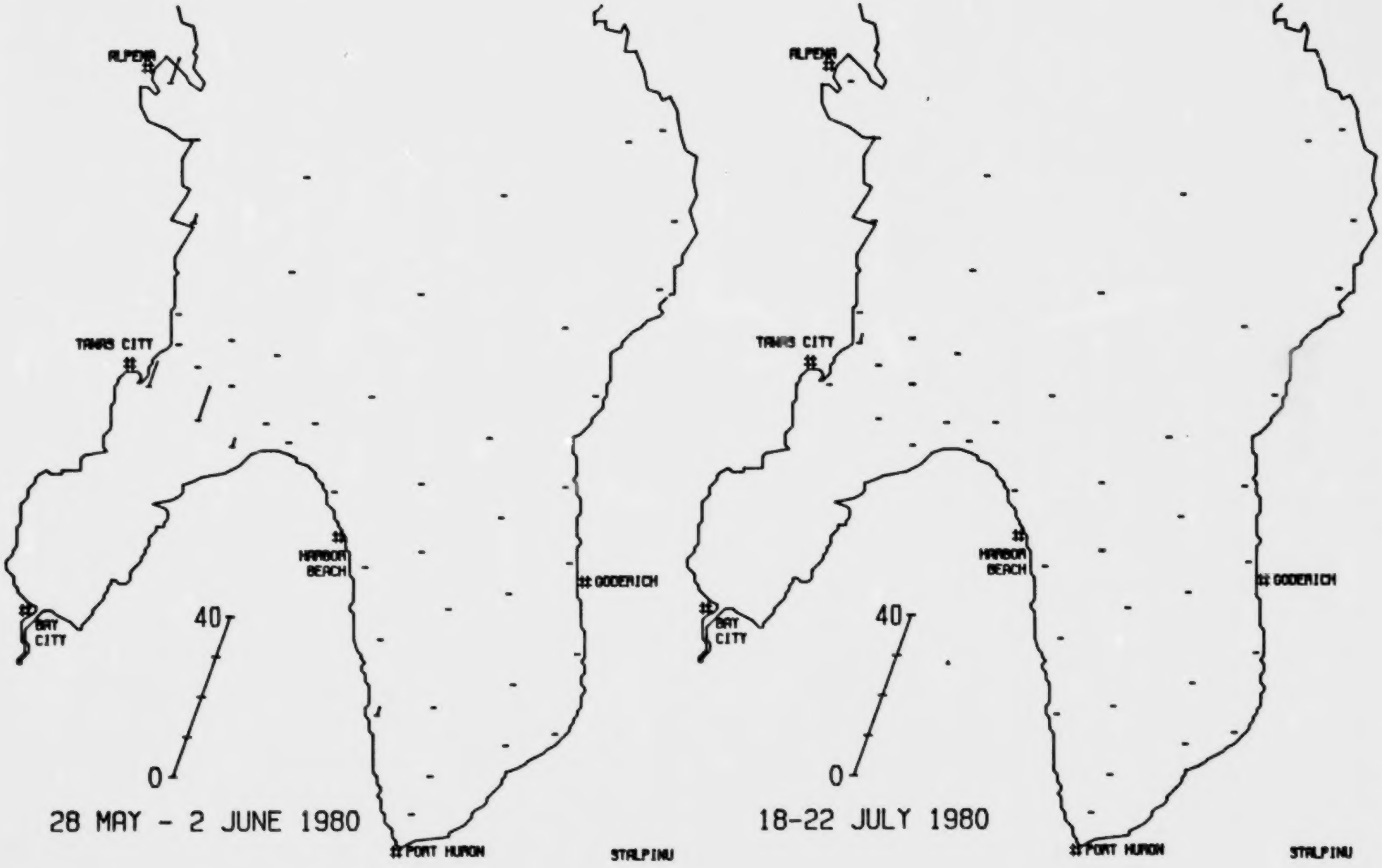
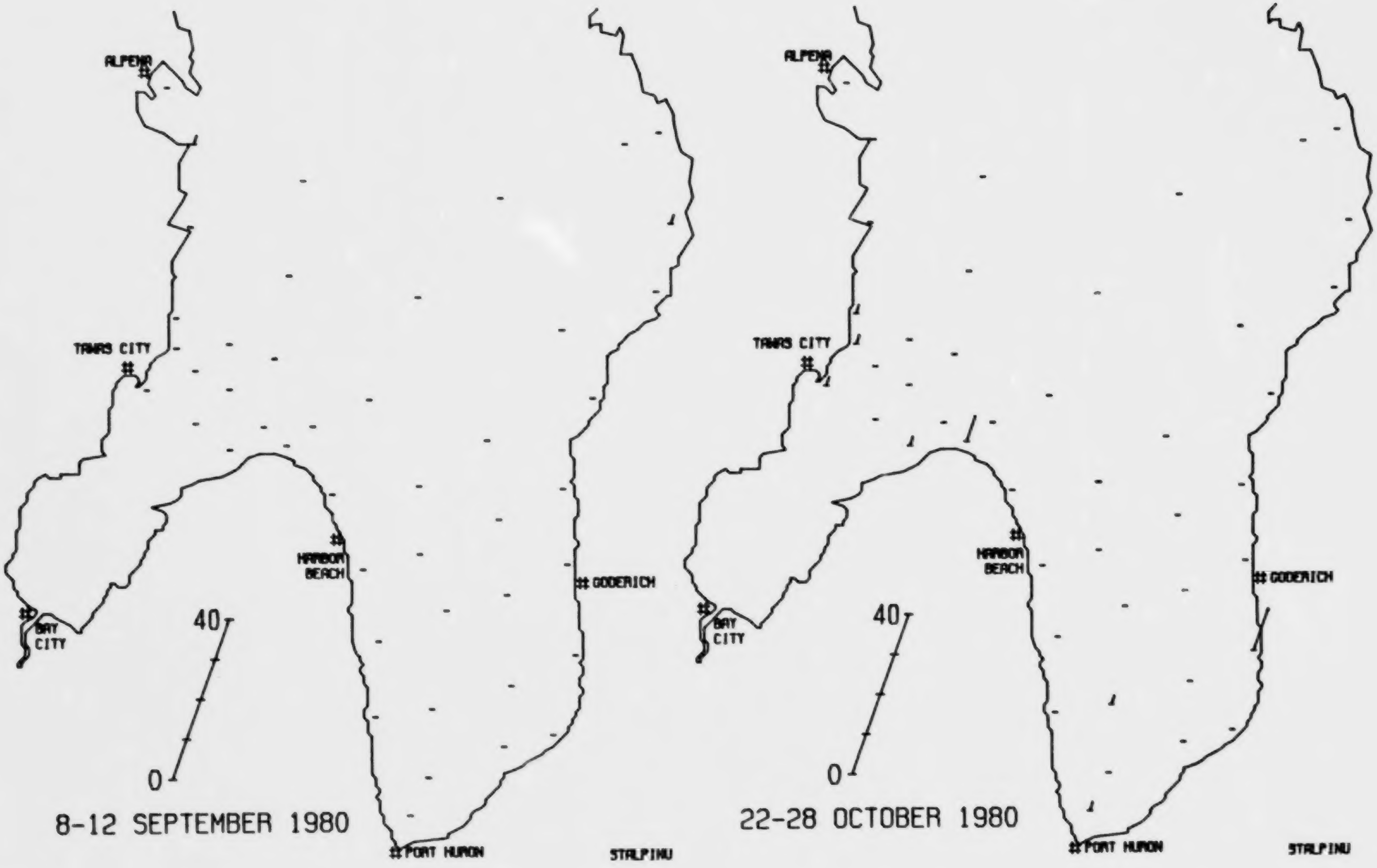

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0
18-22 JULY 1980

Figure 28. (continued)


8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STALPINU
40
0

Figure 28. (continued)

(fig. 29B) it was observed in outer Saginaw Bay and associated waters, reaching its greatest abundance for the season. Similarly in June (fig. 29C) it was only recorded in Saginaw Bay and the U.S. coastline south of the Bay. In October (fig. 29D) a single occurrence was observed north of Tawas City.

Stephanodiscus hantzschii

This species is a small centric form reported from the upper Great Lakes as a minor assemblage component. In April (fig. 30A) this species exhibited its greatest average abundance for the sampling season. Largest cell numbers were seen in outer Saginaw Bay and in the lower U.S. nearshore zone. Moderate abundances were also observed offshore in the southern basin. Erratic distribution was observed in May (fig. 30B) with a large single occurrence south of Goderich. During June (fig. 30C) highest abundances were observed in the offshore central basin with distribution being centered in offshore zones. In September (fig. 30D) low abundances were seen in the Canadian nearshore whereas in October (fig. 30E) most occurrences were reported from Saginaw Bay and adjacent waters.

Stephaodiscus minutus

S. minutus is a commonly reported diatom from the Great Lakes. It may be also reported as S. astrea var. minutula. It attains its greatest cell numbers in the spring and is a common component of disturbed habitats. It was more or less uniformly distributed in April (fig. 31A) with slightly

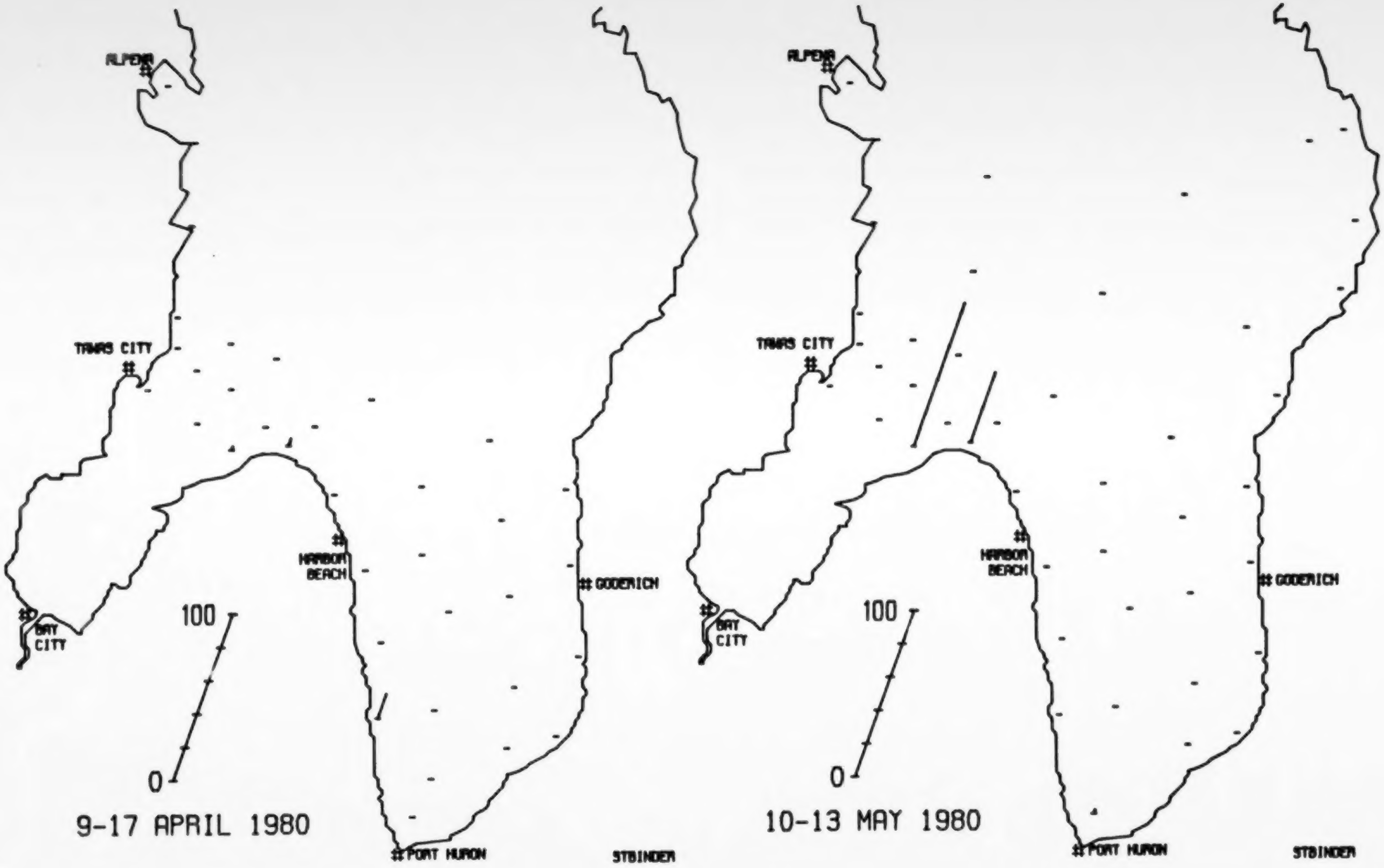

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
100
0
9-17 APRIL 1980
STBINDER
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
100
0
10-13 MAY 1980
STBINDER

Figure 29. Distribution of Stephanodiscus binderanus.

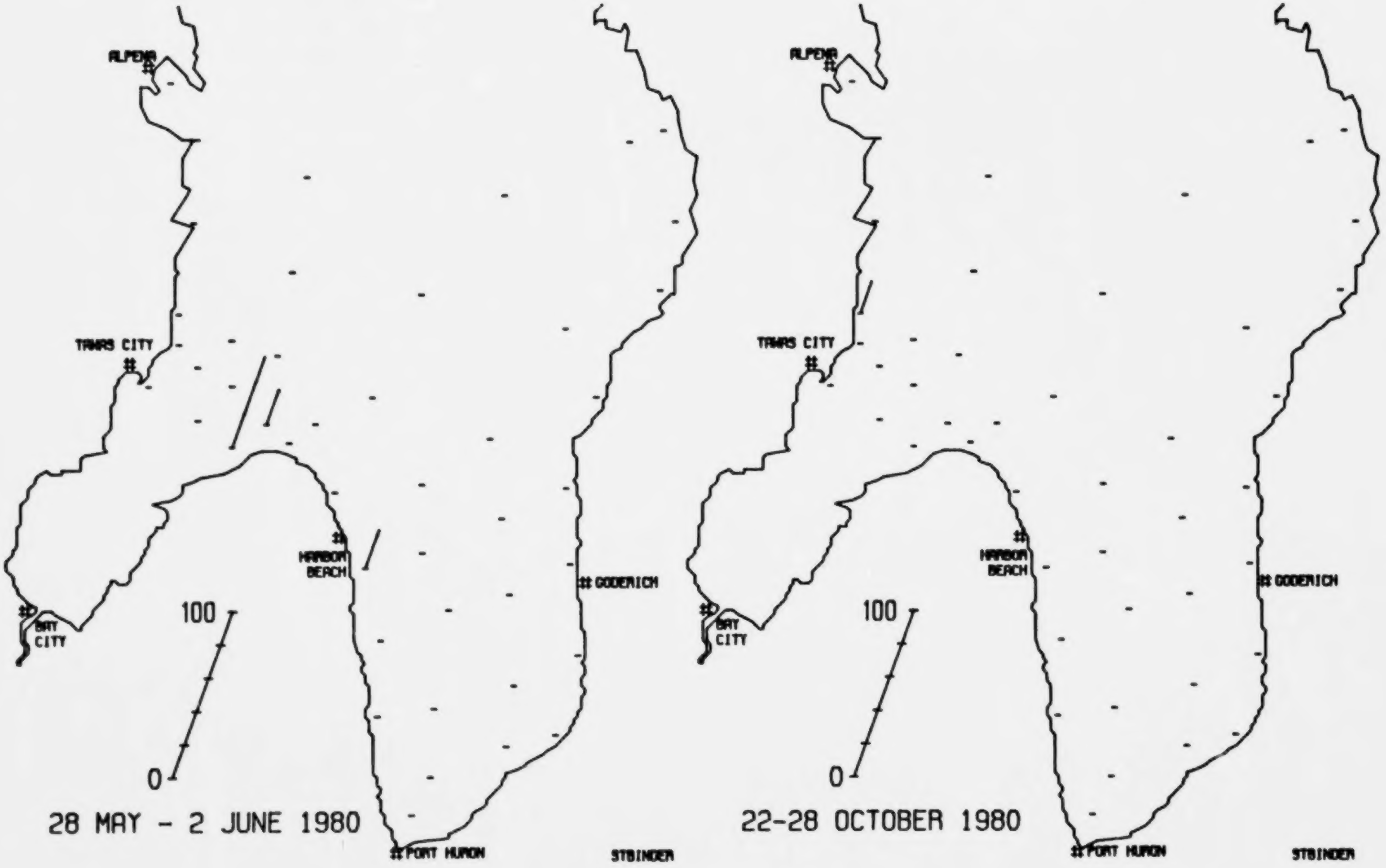

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STBINDER
100
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STBINDER
100
0
22-28 OCTOBER 1980

Figure 29. (continued)

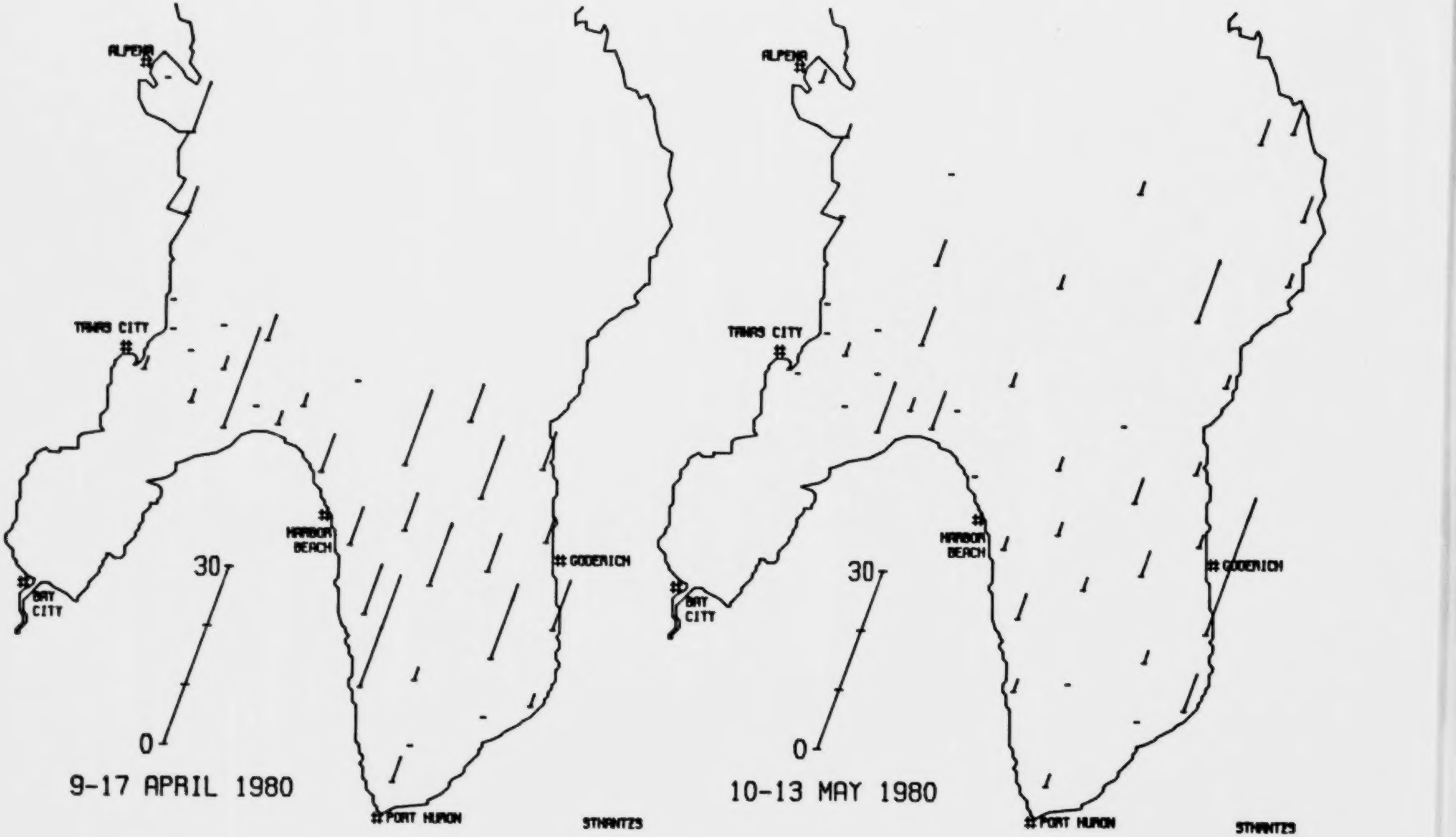
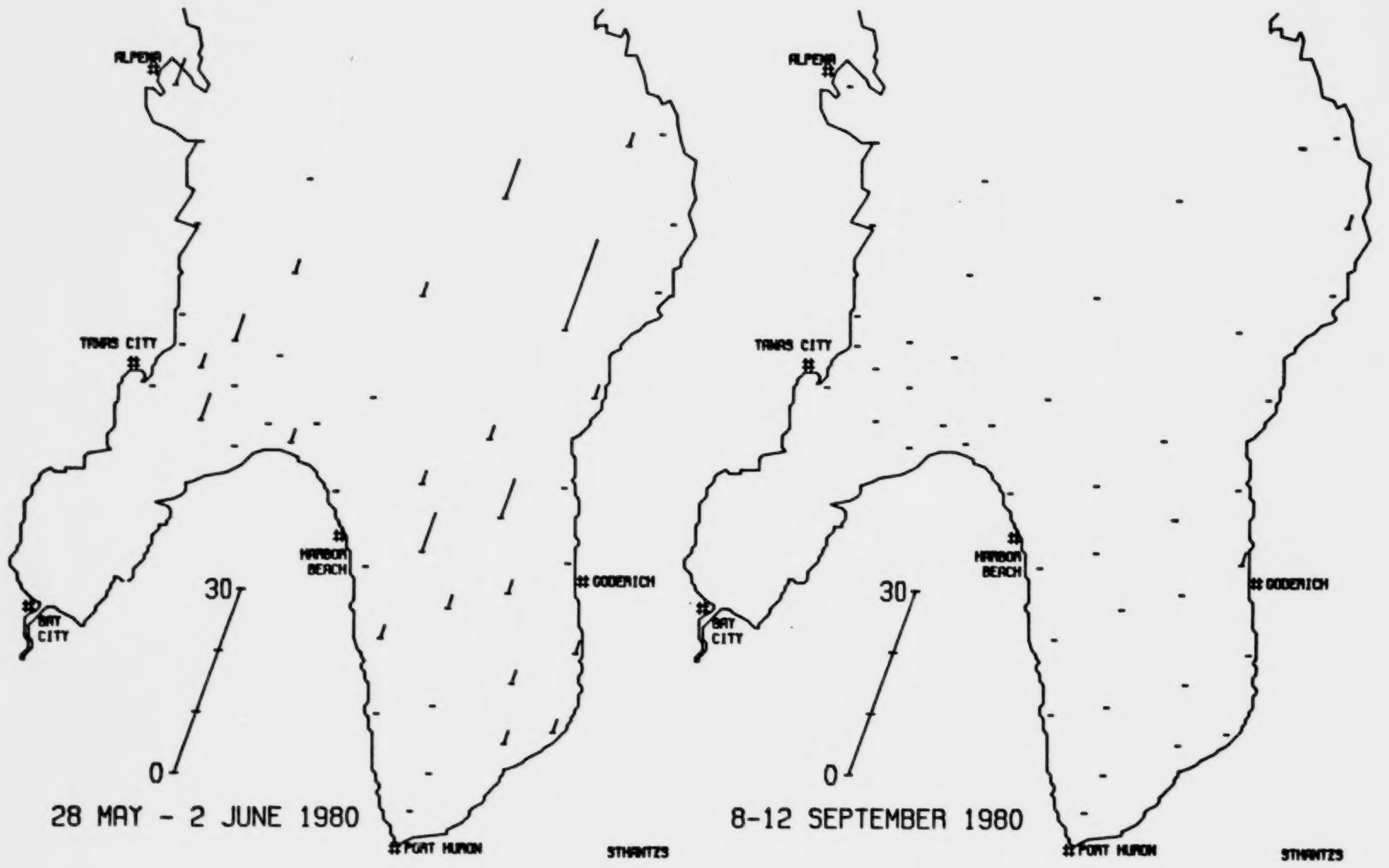

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
30
0
9-17 APRIL 1980
STHANTZS
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
30
0
10-13 MAY 1980
STHANTZS

Figure 30. Distribution of Stephanodiscus hantzschii.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
30
0
STHANTZ3
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
30
0
STHANTZ3

28 MAY - 2 JUNE 1980

8-12 SEPTEMBER 1980

Figure 30. (continued)

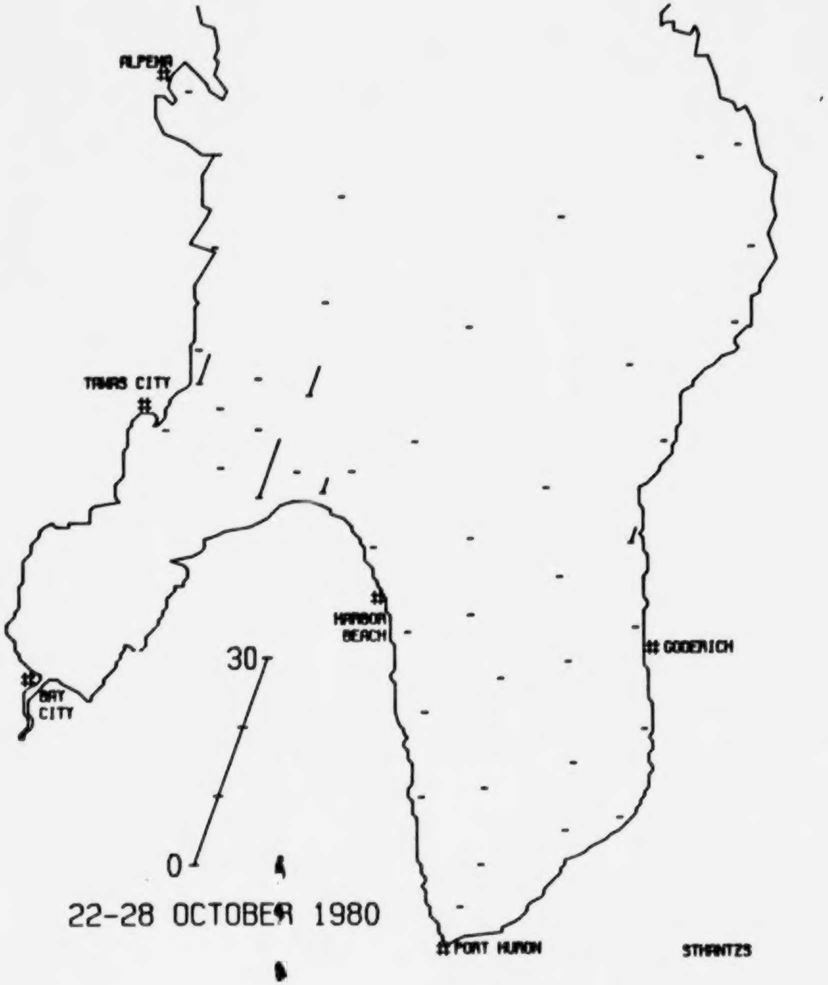

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STHANTZ3
30
0
22-28 OCTOBER 1980

Figure 30. (continued)

elevated abundances in the offshore waters of the southern basin. In May (fig. 31B) it exhibited reduced abundances with peaks south of Goderich and larger abundances in the central basin compared to the southern. During June (fig. 31C) high abundances were observed in the offsore central basin and decreasing in abundance towards the upper southern basin. During July (fig. 31D) a few sporadic occurrences were observed on the northern U.S. shore. Conversely, in September (fig. 31E) very low abundances were observed in the central basin nearshore zone and the lowermost portion of the southern basin. In October (fig. 31F) slightly higher abundance were observed primarily located in the central basin.

Stephanodiscus subtilis

S. subtilis is reported from enriched harbors and rivermouth areas from the Great Lakes. This taxon may be synonymous with *S. invisitatus* Hohn and Hellerman (Hohn and Hellerman 1963). In all months sampled (figs. 32A-32D) this species was observed in the Canadian nearshore zone south of Goderich. It reached its single largest abundance in June.

Synedra filiformis

This species may be present in the spring or fall months, sometimes showing responses to nutrient enrichment. In April (fig. 33A) this species reached its highest abundance of the cruise season. Greatest abundances were observed in the nearshore zone in Saginaw Bay and south of the Bay. In May (fig. 33B) it was widely distributed

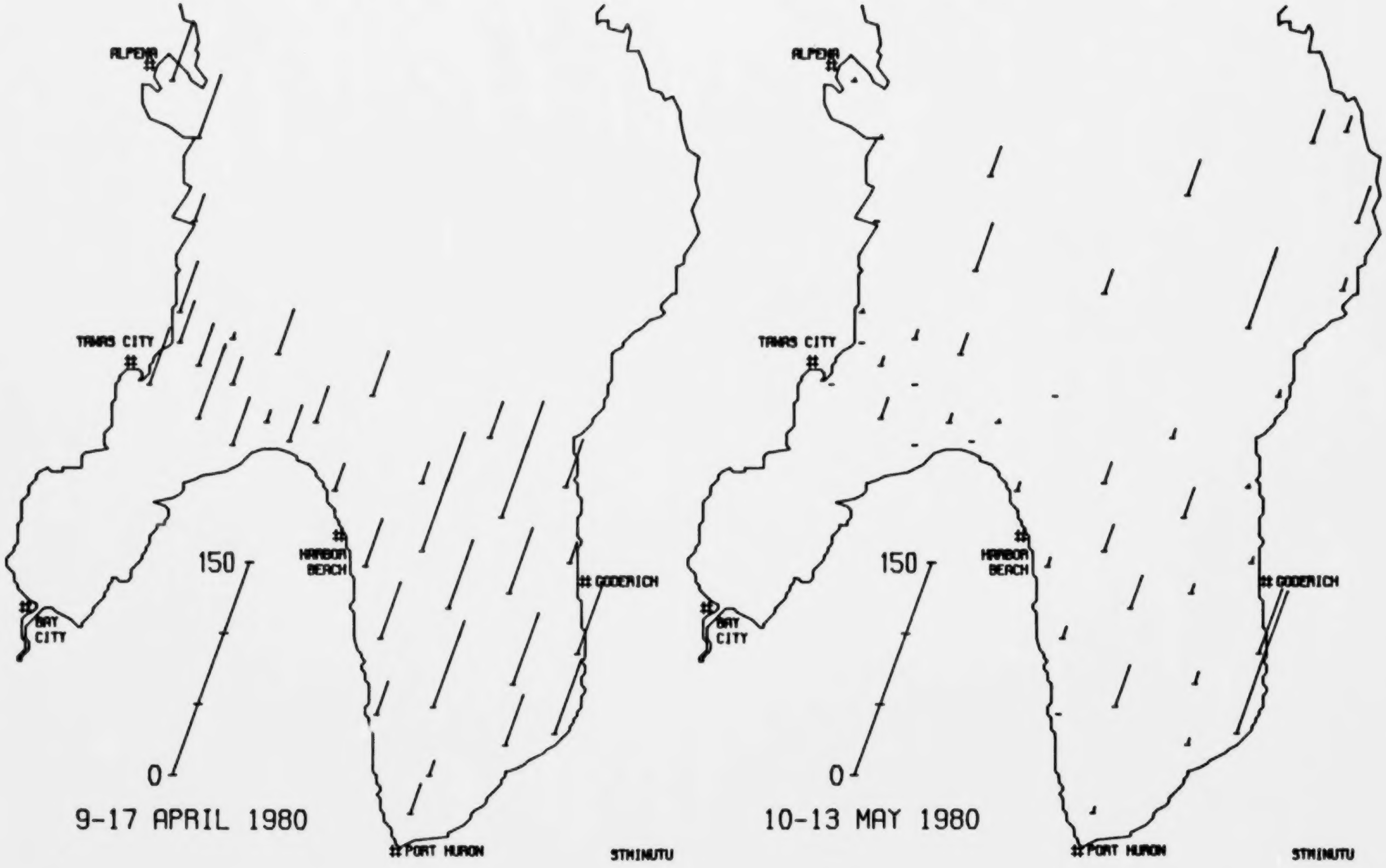

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
150
0
9-17 APRIL 1980
STMINUTU
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
150
0
10-13 MAY 1980
STMINUTU

Figure 31. Distribution of Stephanodiscus minutus.

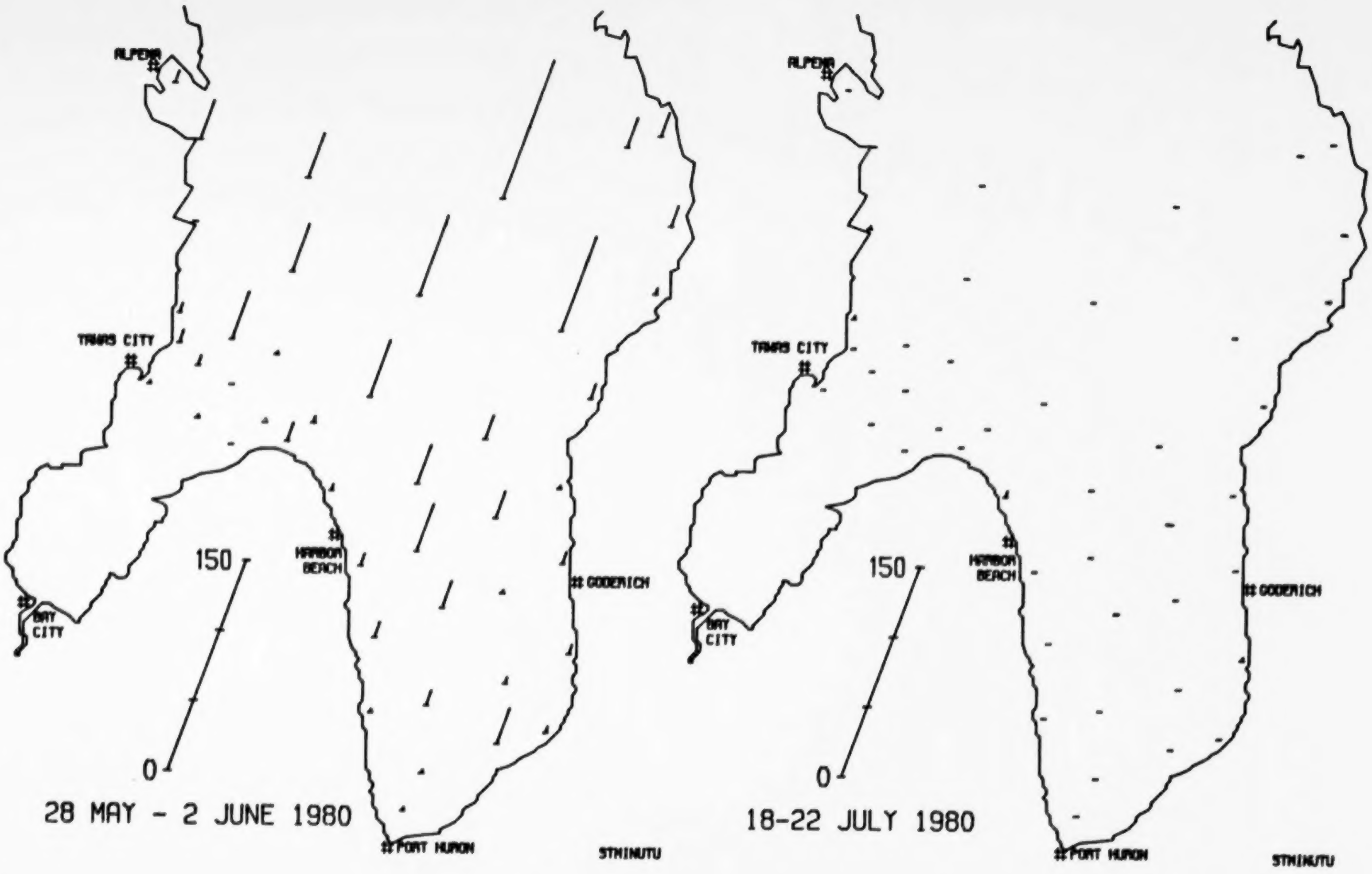
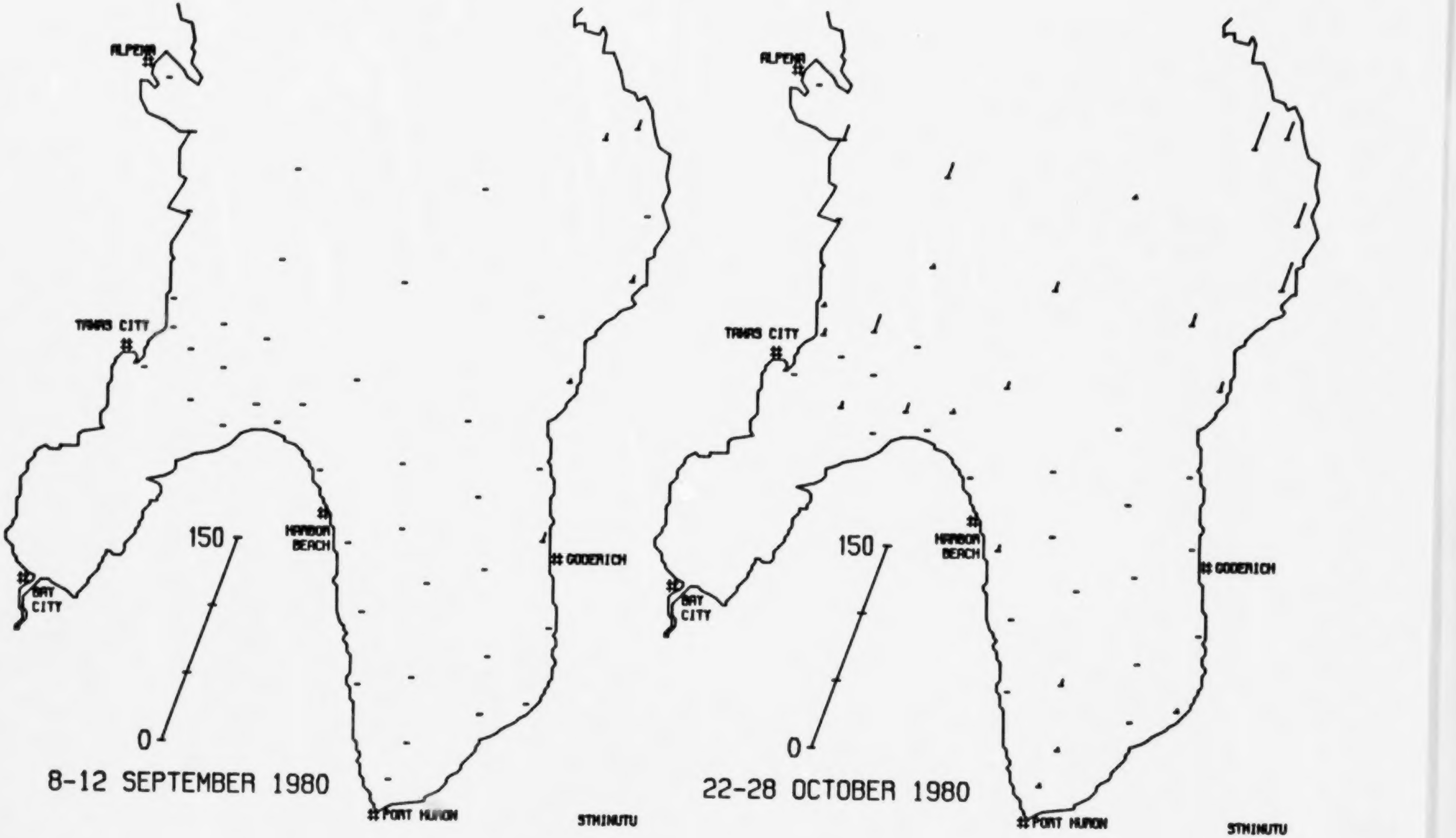

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STNINUTU
150
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STNINUTU
150
0
18-22 JULY 1980

Figure 31. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
STNINUTU
150
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
STNINUTU
150
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 31. (continued)

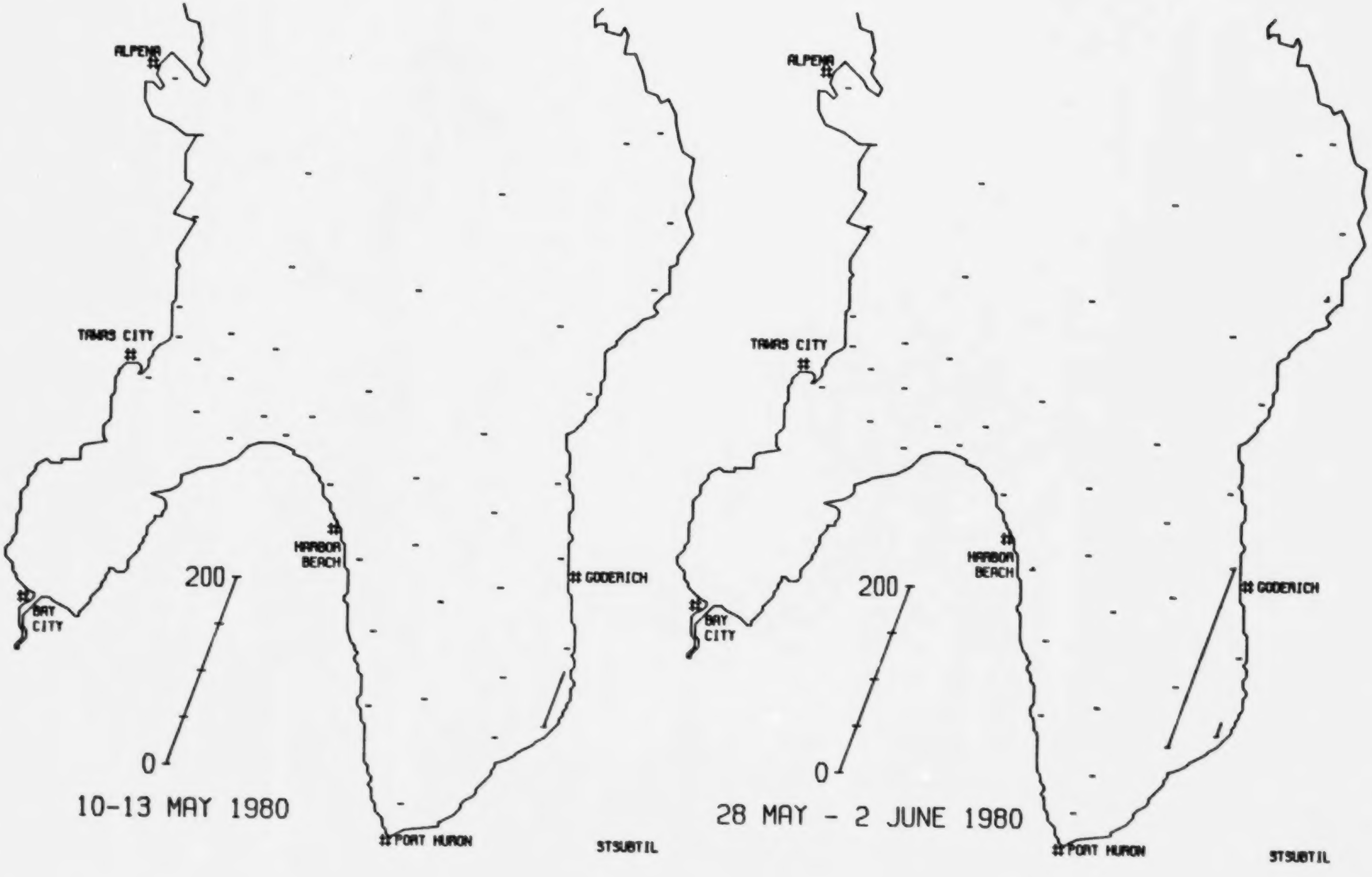

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
200
0
10-13 MAY 1980
STSUBTIL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
200
0
28 MAY - 2 JUNE 1980
STSUBTIL

Figure 32. Distribution of Stephanodiscus subtilis.

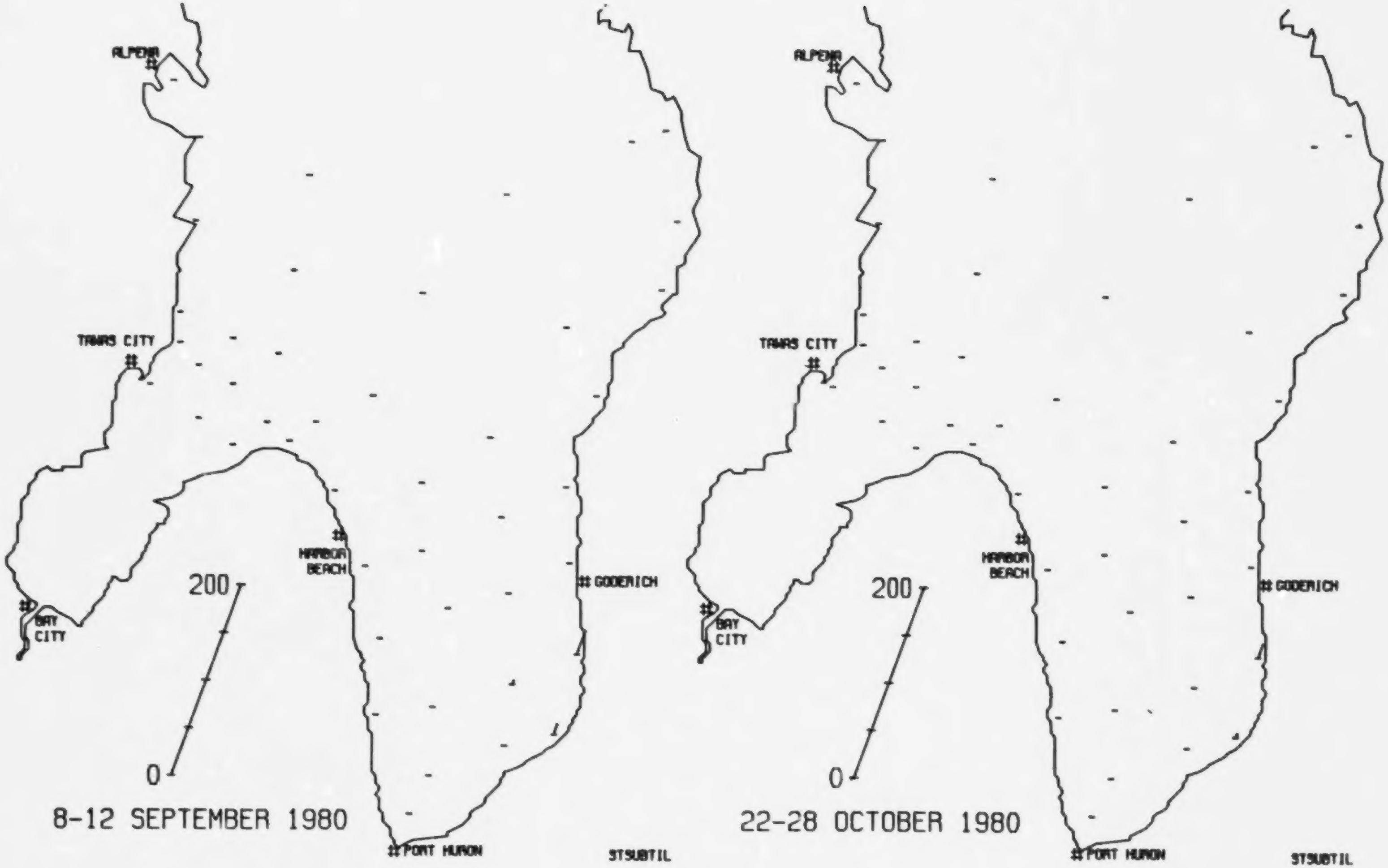

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STSUBTIL
200
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STSUBTIL
200
0
22-28 OCTOBER 1980

Figure 32. (continued)

throughout the study area. It was most abundant in the nearshore zone around the entire lake perimeter but at comparatively lower abundances to the preceeding month. During June (fig. 33C) slightly lower abundances were recorded showing a uniform distribution. During July and September (figs. 33D and 33E) few or no occurrences were observed. In October (fig. 33F) slightly increased values were observed over the study area with a wider distribution.

Synedra ostenfeldii

This species usually exhibits greatest abundance and occurrence during the spring months, as was observed in this study. In April (fig. 34A) it showed highest concentrations in the nearshore zone on the U.S. coastline. During May (fig. 34B) it again reached greatest abundance in coastal zones around the study area but was observed in the offshore waters of both basins. In June (fig. 34C) it attained its greatest cell concentrations for the season. It was widespread throughout the study area with most peaks in the central basin. Cell numbers were greatly reduced in July (fig. 34D) and was restricted to the central basin. It was recorded in very low abundances with sporadic distribution in October (fig. 34E)

Tabellaria fenestrata

This chain-forming species is commonly observed in the net plankton from all of the Great Lakes. In April (fig. 35A) it was uniformly distributed over the southern basin with slightly elevated cell densities in the nearshore

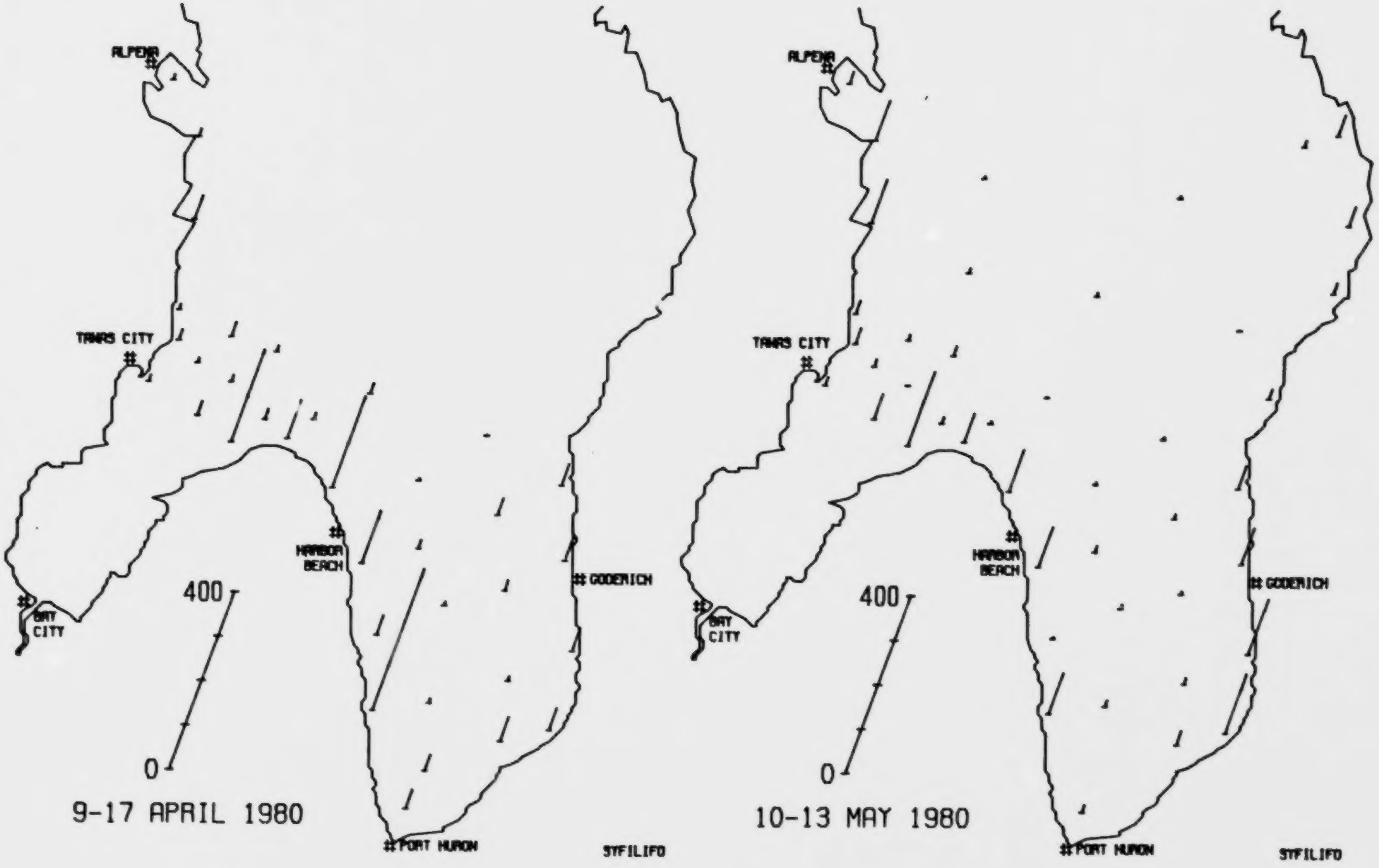

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
9-17 APRIL 1980
SYFILIFO
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
10-13 MAY 1980
SYFILIFO

Figure 33. Distribution of Syndera filiformis.

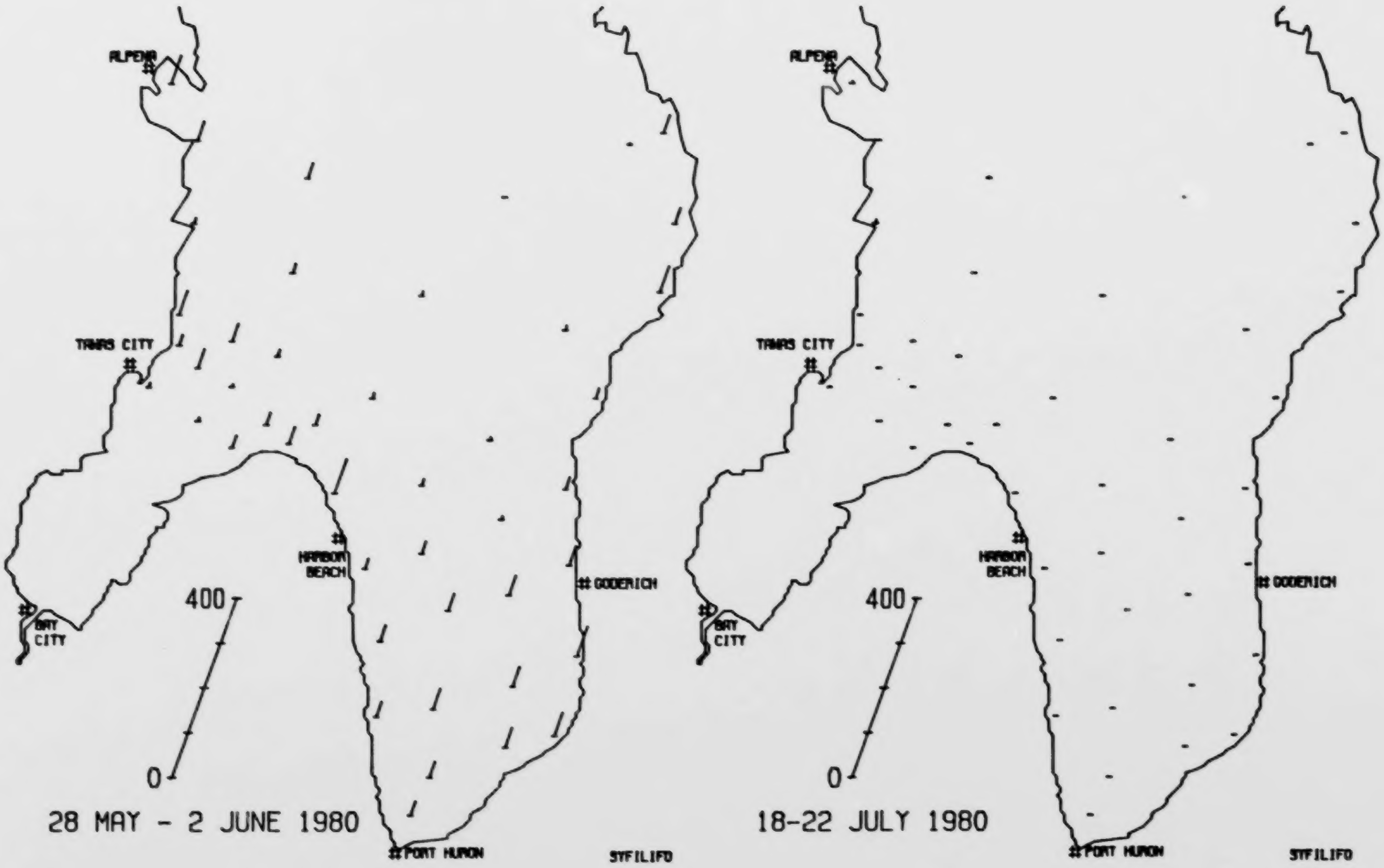
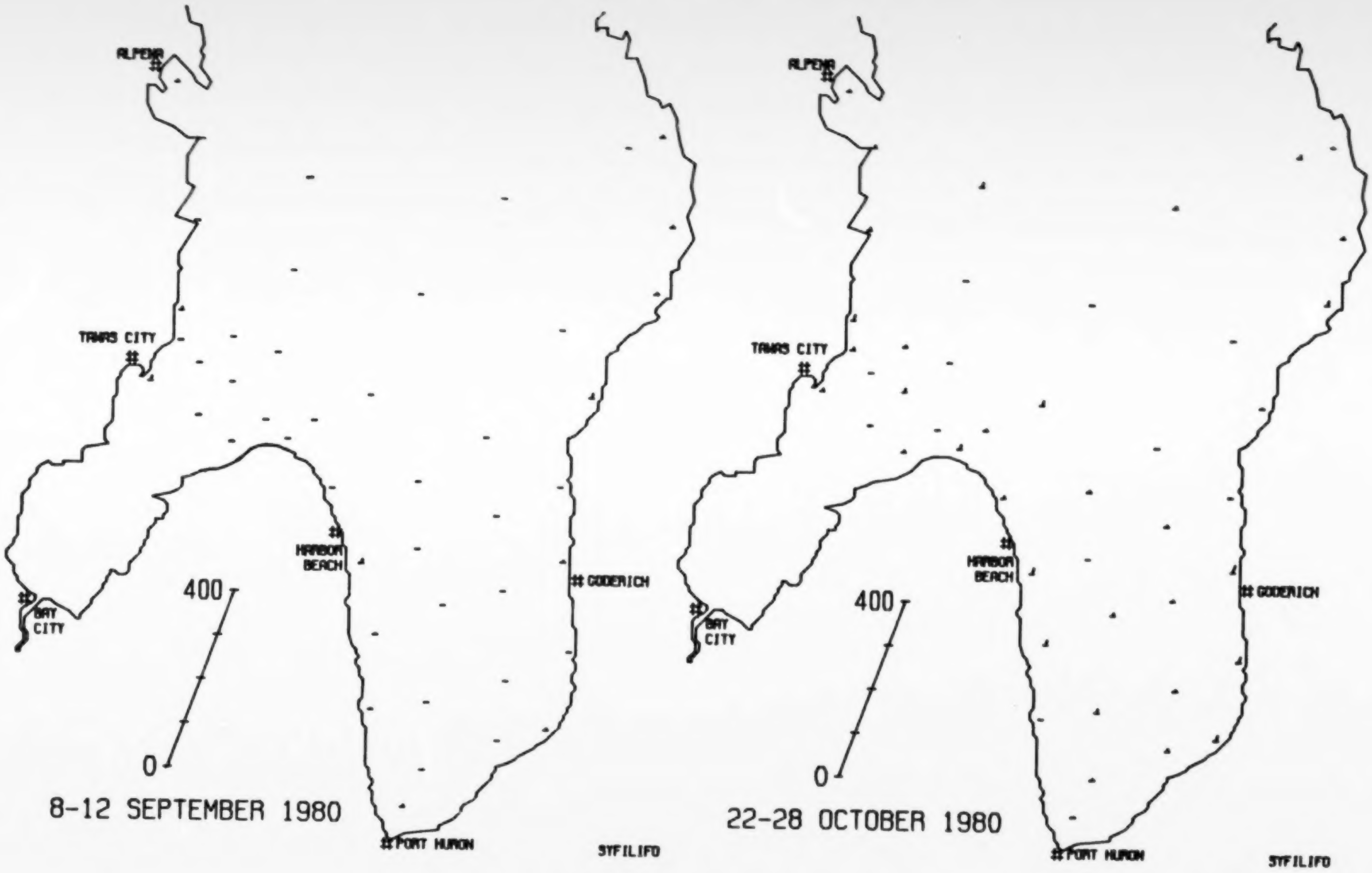

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STFILIFD
400
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
STFILIFD
400
0
18-22 JULY 1980

Figure 33. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
400
0
SYFILIFO
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
400
0
SYFILIFO

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 33. (continued)

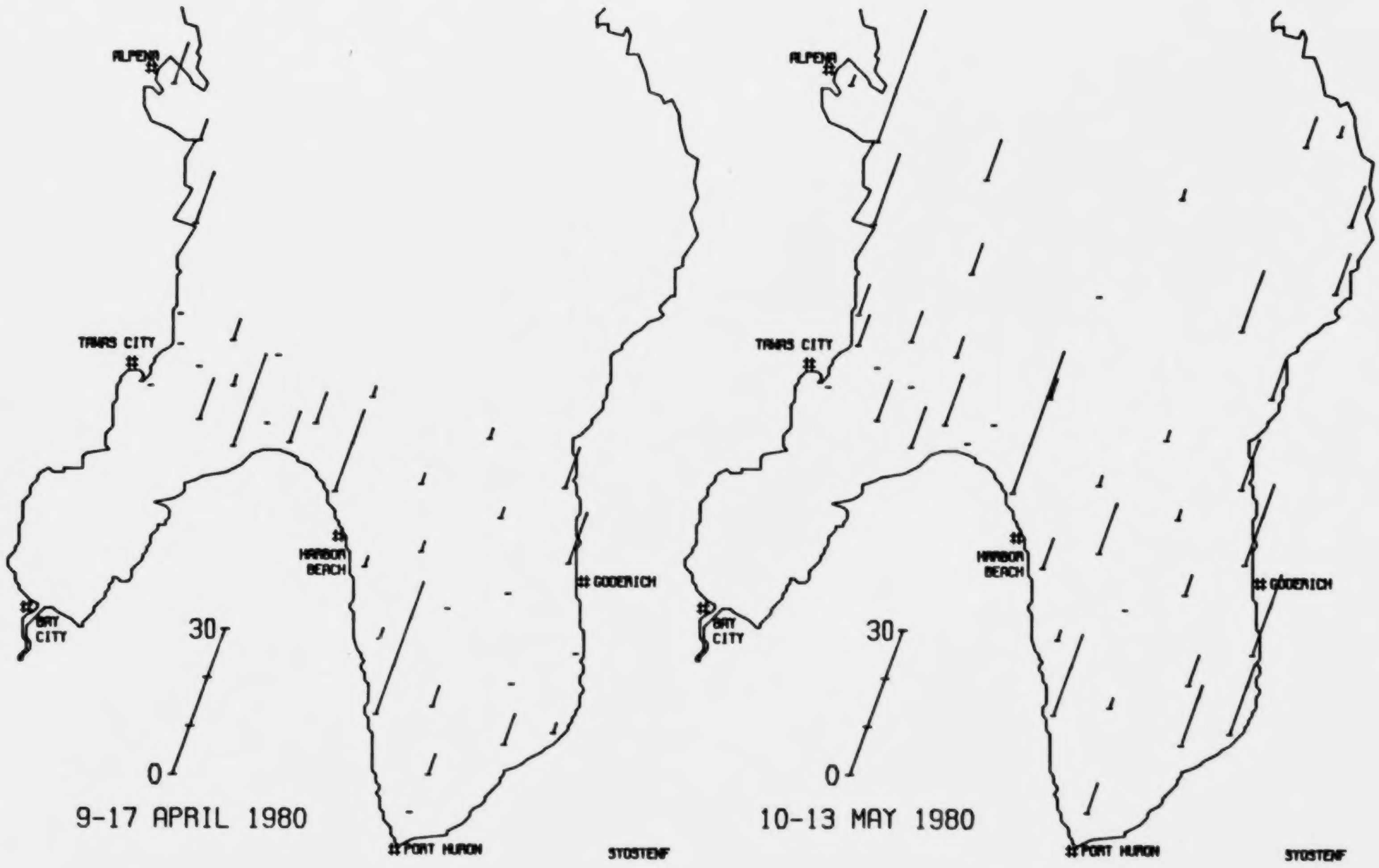
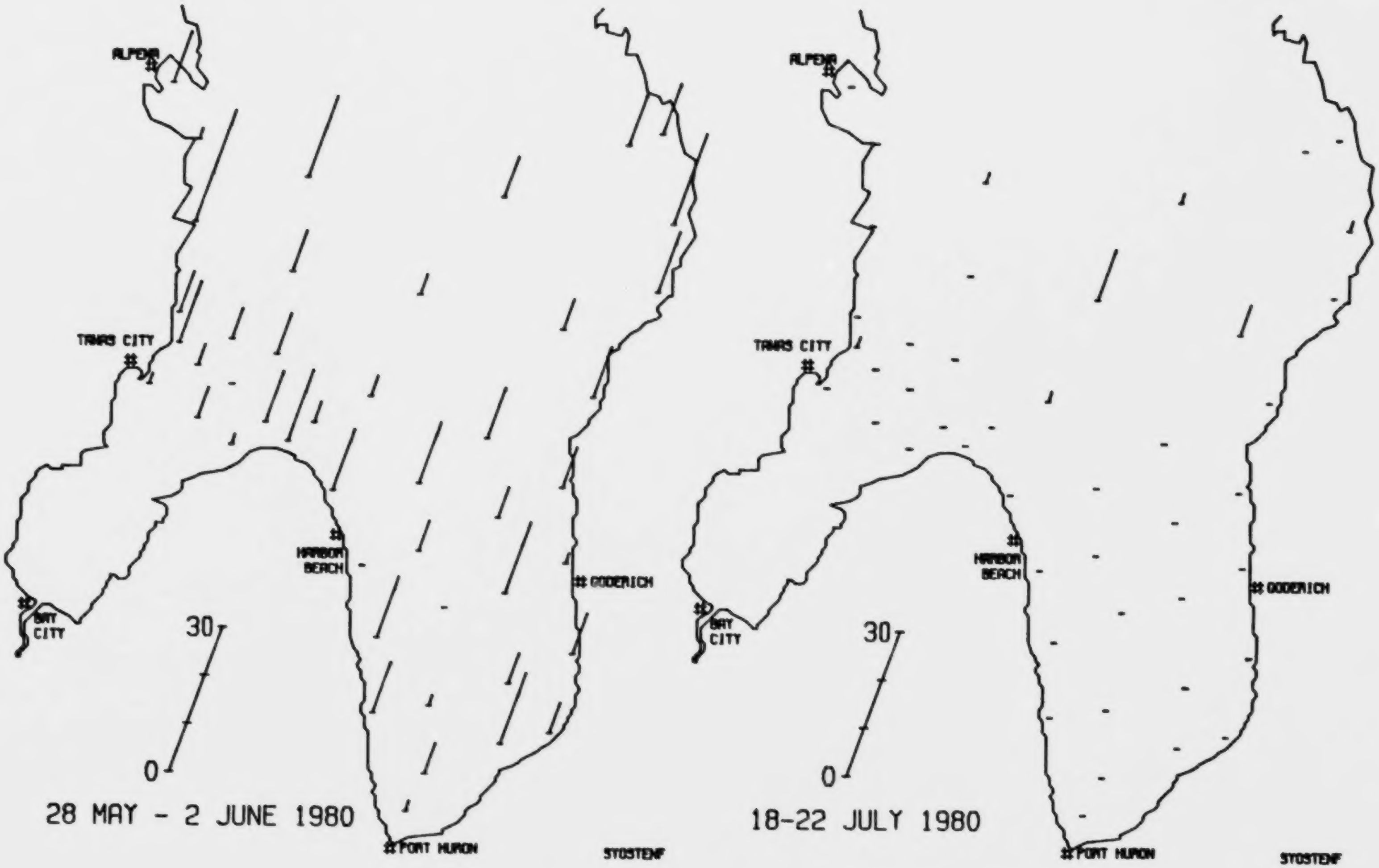

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
30
0
9-17 APRIL 1980
SYOSTENF
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
30
0
10-13 MAY 1980
SYOSTENF

Figure 34. Distribution of *Synedra* *ostenfeldii*.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
30
0
SYOSTENF
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
30
0
SYOSTENF

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 34. (continued)

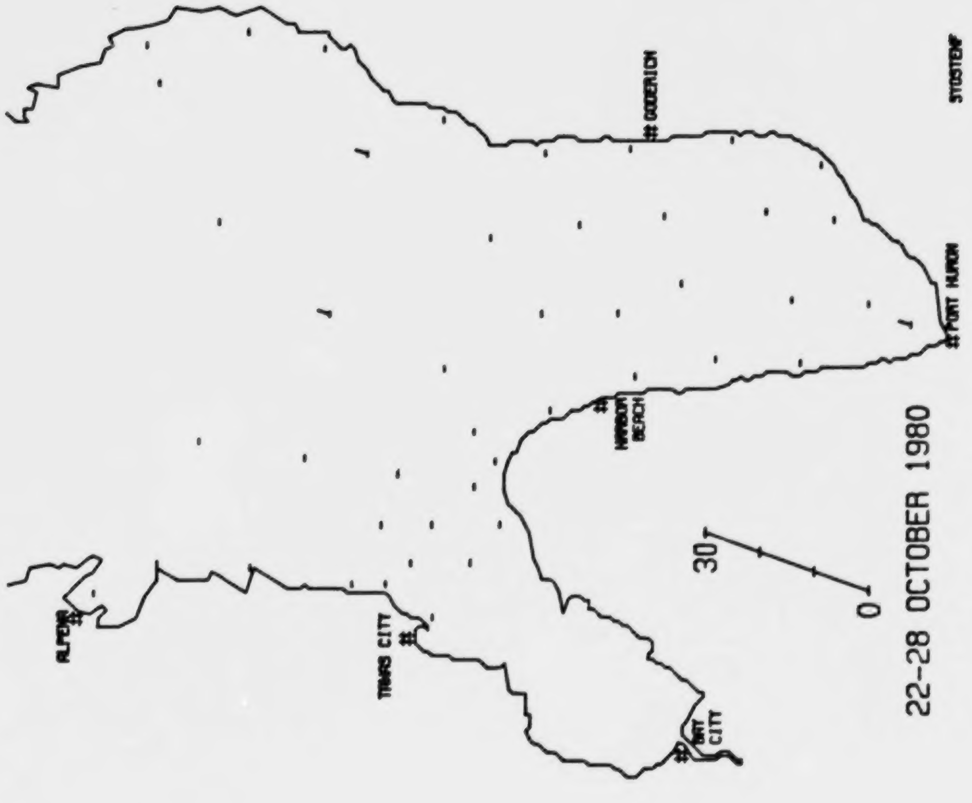

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
STOSTEMP
30
0
22-28 OCTOBER 1980

Figure 34. (continued)

zone of the U.S. coastline. In May (fig. 35B) highest abundances were seen near Thunder Bay but it was widespread over the study area. This species was again found throughout the study area in June (fig. 35C) with peaks in the nearshore zone south of Goderich. Greatly reduced occurrences and abundances were observed for July (fig. 35D) with occurrences primarily in the nearshore area between Alpena and Tawas City. Extremely low cell densities were seen in September (fig. 35E) with slightly increased abundances in October (fig. 35F).

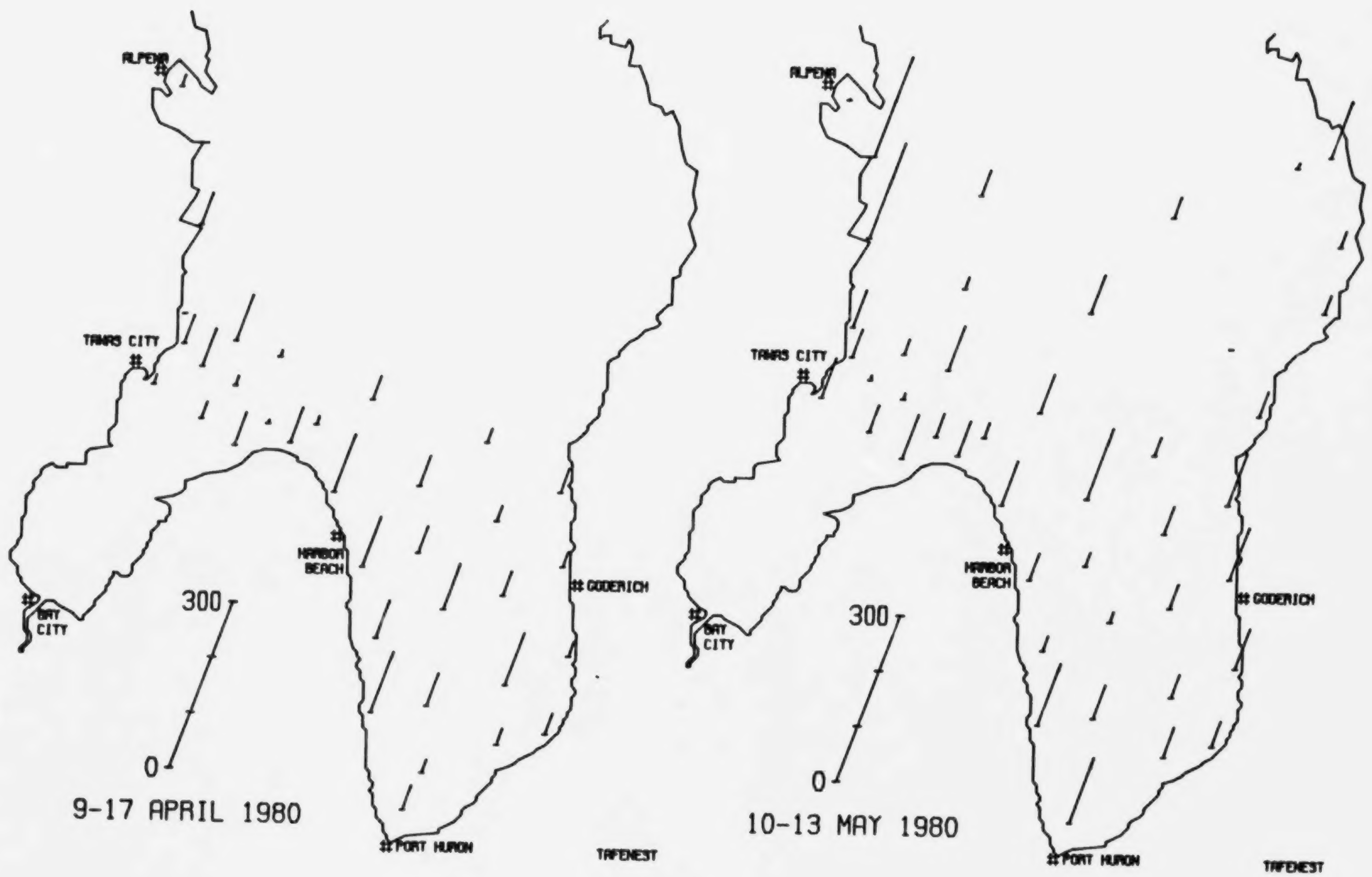

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
0
9-17 APRIL 1980
TAFENEST
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
300
0
10-13 MAY 1980
TAFENEST

Figure 35. Distribution of Tabellaria fenestrata.

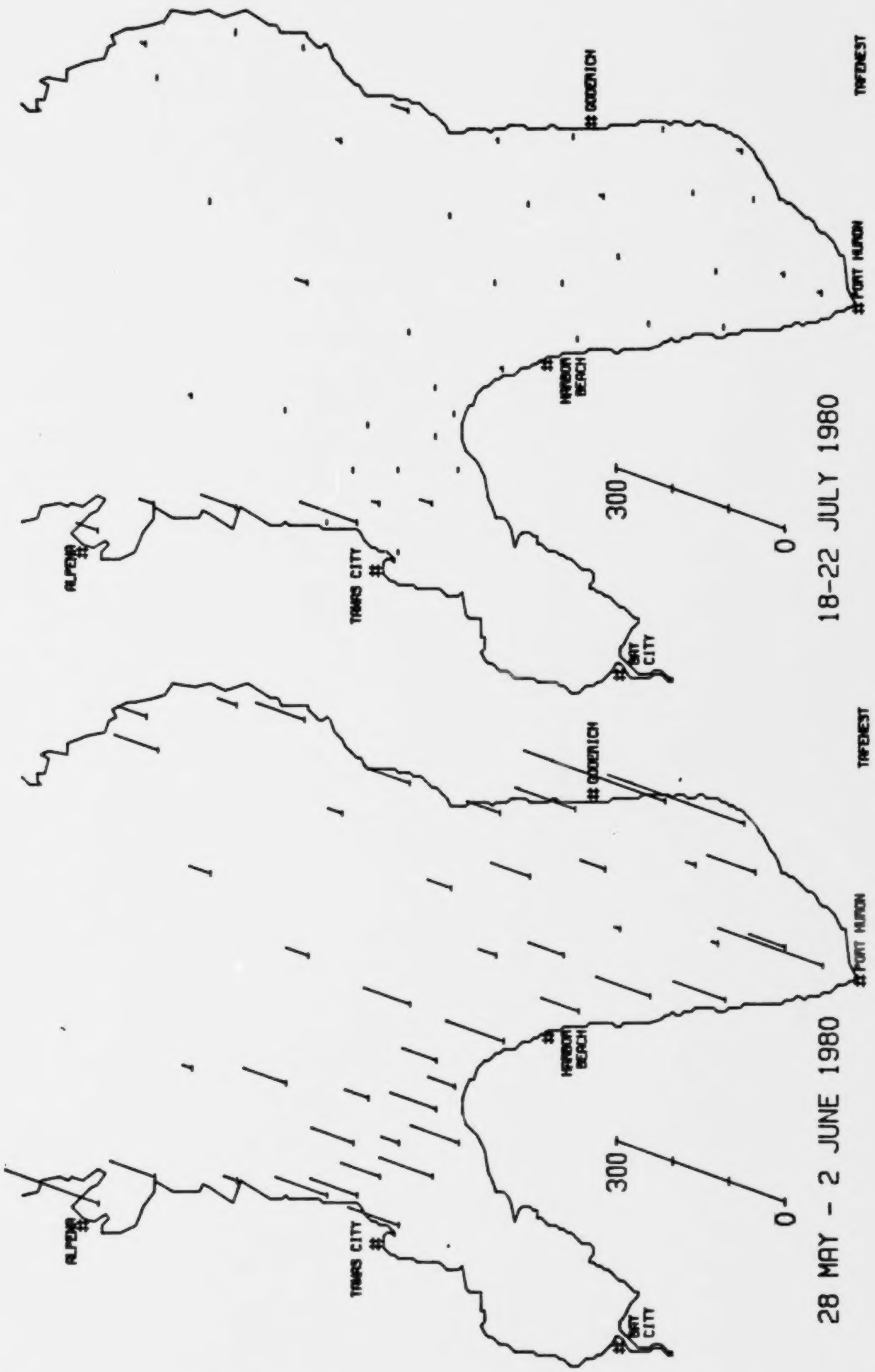

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
TAFENEST
300
0
18-22 JULY 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
TAFENEST
300
0
28 MAY - 2 JUNE 1980

Figure 35. (continued)

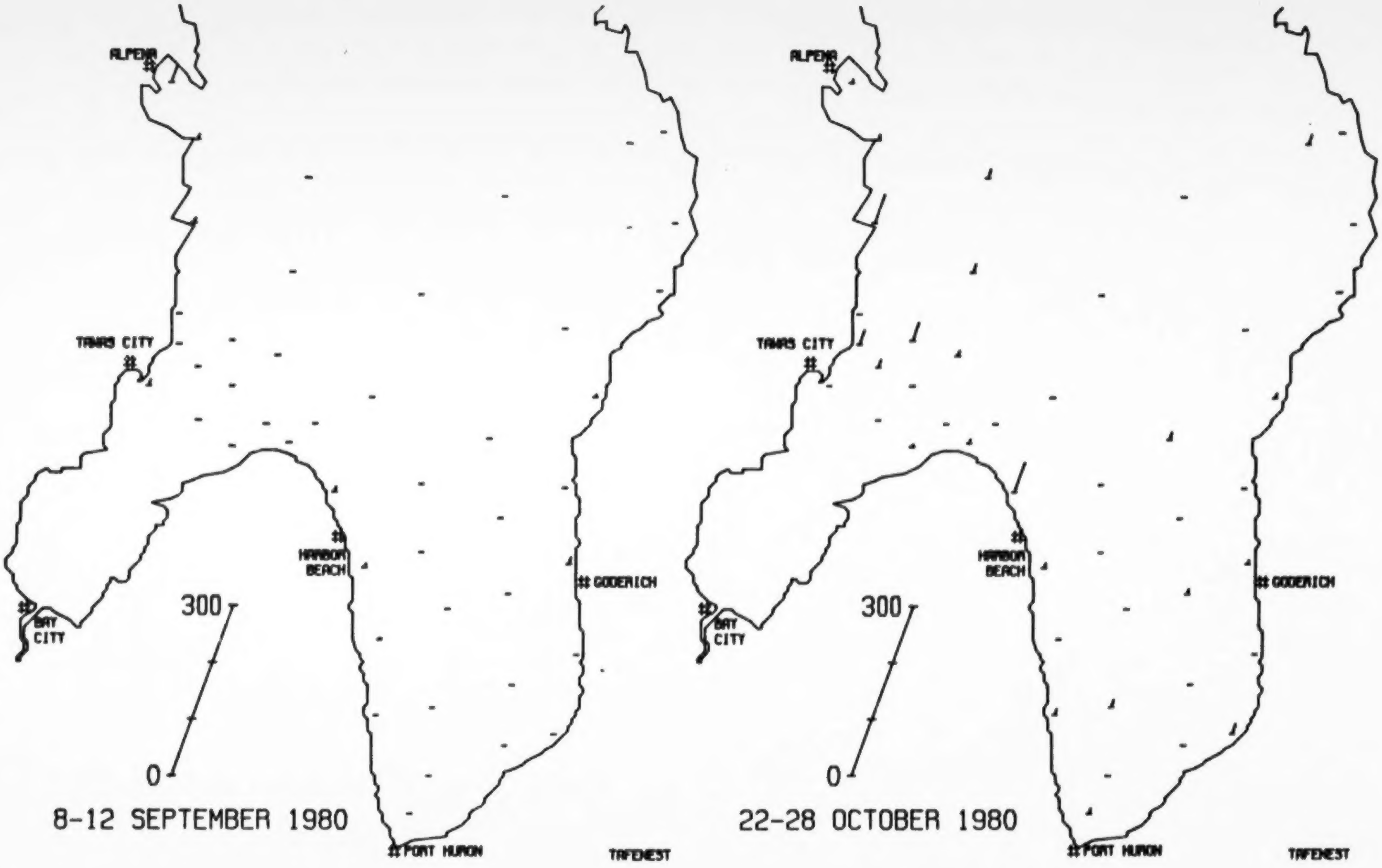

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
TAFENEST
300
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
TAFENEST
300
0
22-28 OCTOBER 1980

Figure 35. (continued)

CHLOROPHYTA - GREEN ALGAE

Green algae are most commonly observed in productive ponds and shallow lakes (Hutchinson 1967) usually in the summer months. In the Great Lakes, they are recorded in highest abundance during the summer in enriched areas, ie. the western basin of Lake Erie (Munawar and Munawar 1976), however some genera are noted during other seasons in offshore waters. In southern Lake Huron, members of this group exhibited extremely erratic distributions. In April (fig. 36A) abundances were fairly low with greatest cell numbers observed north of Tawas City and the mid-southern basin. During May (fig. 36B) highest standing crops were observed in nearshore zones, particularly in the southern basin. A large peak was seen on the Canadian shoreline in the northern portion of the central basin. Moderate abundances were seen in outer Saginaw Bay and in the lower central basin. Highest standing crop for June (fig. 36C) were in the southern basin. Several moderate abundances were observed in outer Saginaw Bay and northward from the Bay. In July (fig. 36D) highest abundance was seen in outer Saginaw Bay and its associated waters. Some moderate abundances were observed near Alpena and southward. Distinctly less abundance was recorded through the remainder of the study area. In September (fig. 36E) very large cell densities were recorded at one station in the offshore waters on the west side of the central basin. Moderate abundances were observed over the study area with slightly elevated abundances in waters adjacent to Saginaw Bay and comparatively small abundances on the entire Canadian coastline. Greatest abundances of green algae were observed in the area adjacent to Saginaw Bay in October (fig. 36F). Higher standing crops were observed in the southern basin compared to the central basin.

Ankistrodesmus sp. #3

This green alga is not satisfactorily placed at the species level. It has morphological characteristics similar to *Ankistrodesmus falcatus* and may be an undescribed form of the species. Uniform low abundances were seen in April (fig. 37A) with slightly elevated cell numbers in nearshore zones and outer Saginaw Bay. In May (fig. 37B) cell densities slightly increased, still with the highest abundances in coastal areas. Highest abundances in June (fig. 37C) were recorded in outer Saginaw Bay and the interface zone. Low abundance was observed in offshore waters excepting a north-south transect of stations in the mid-southern basin. In July (fig. 37D) a very large population was observed in the littoral zone between Alpena and Tawas City. High values were also observed in the Saginaw Bay associated waters, and in general, abundances were largest on the western side of the study area. During September and October (figs. 37F and 37E) abundances were markedly reduced and revealed no apparent distributional trends.

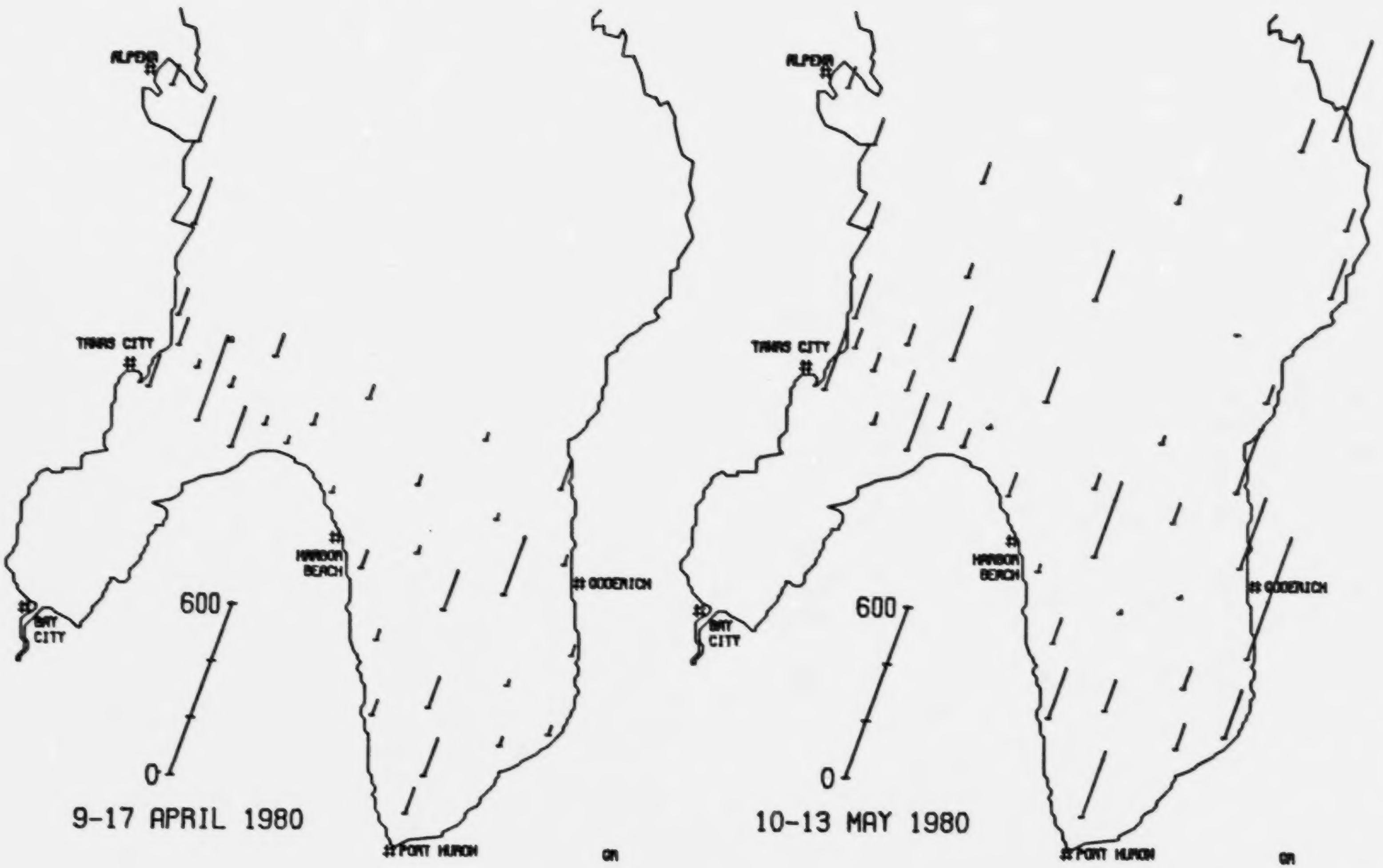
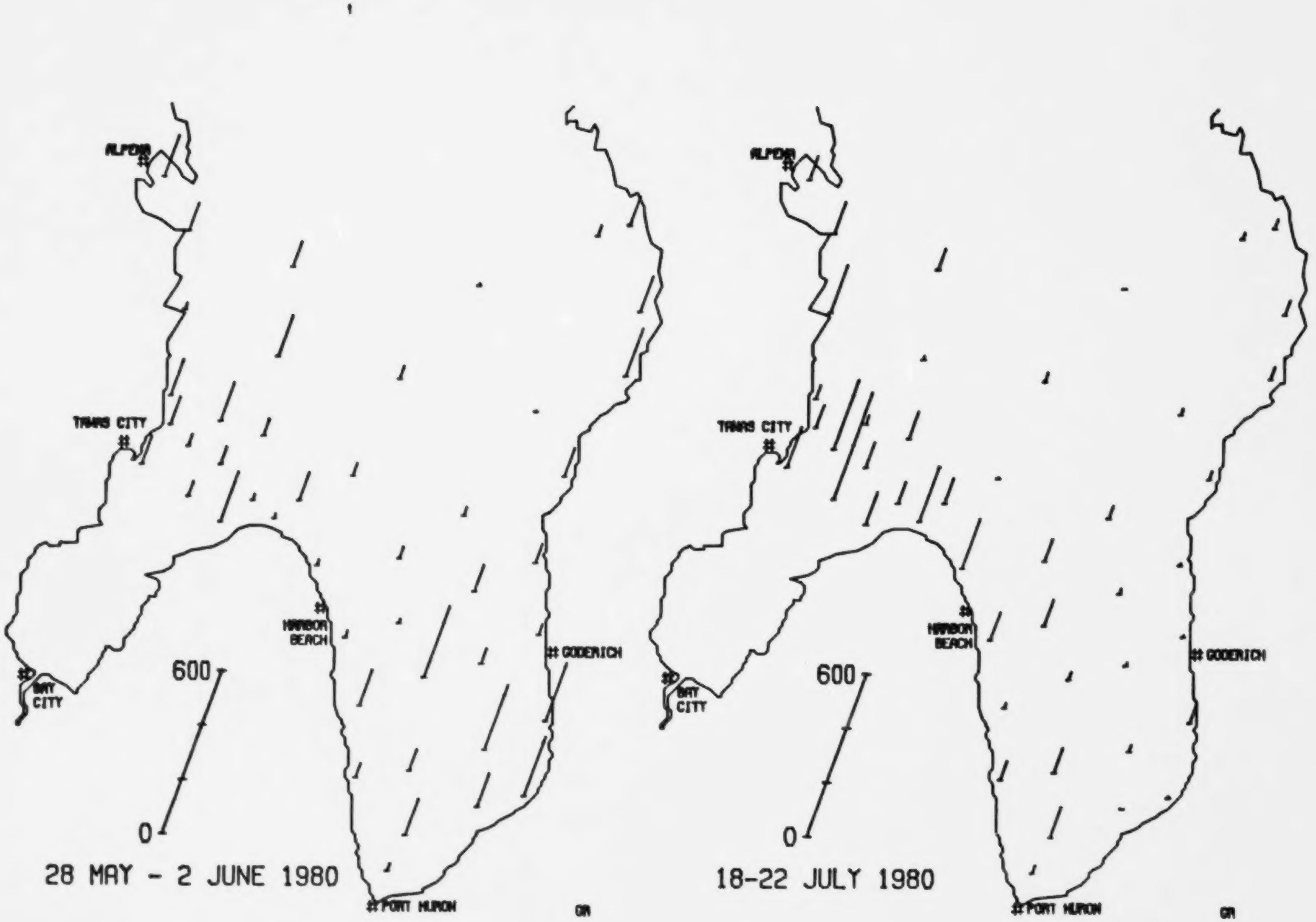

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GR
600
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GR
600
0
10-13 MAY 1980

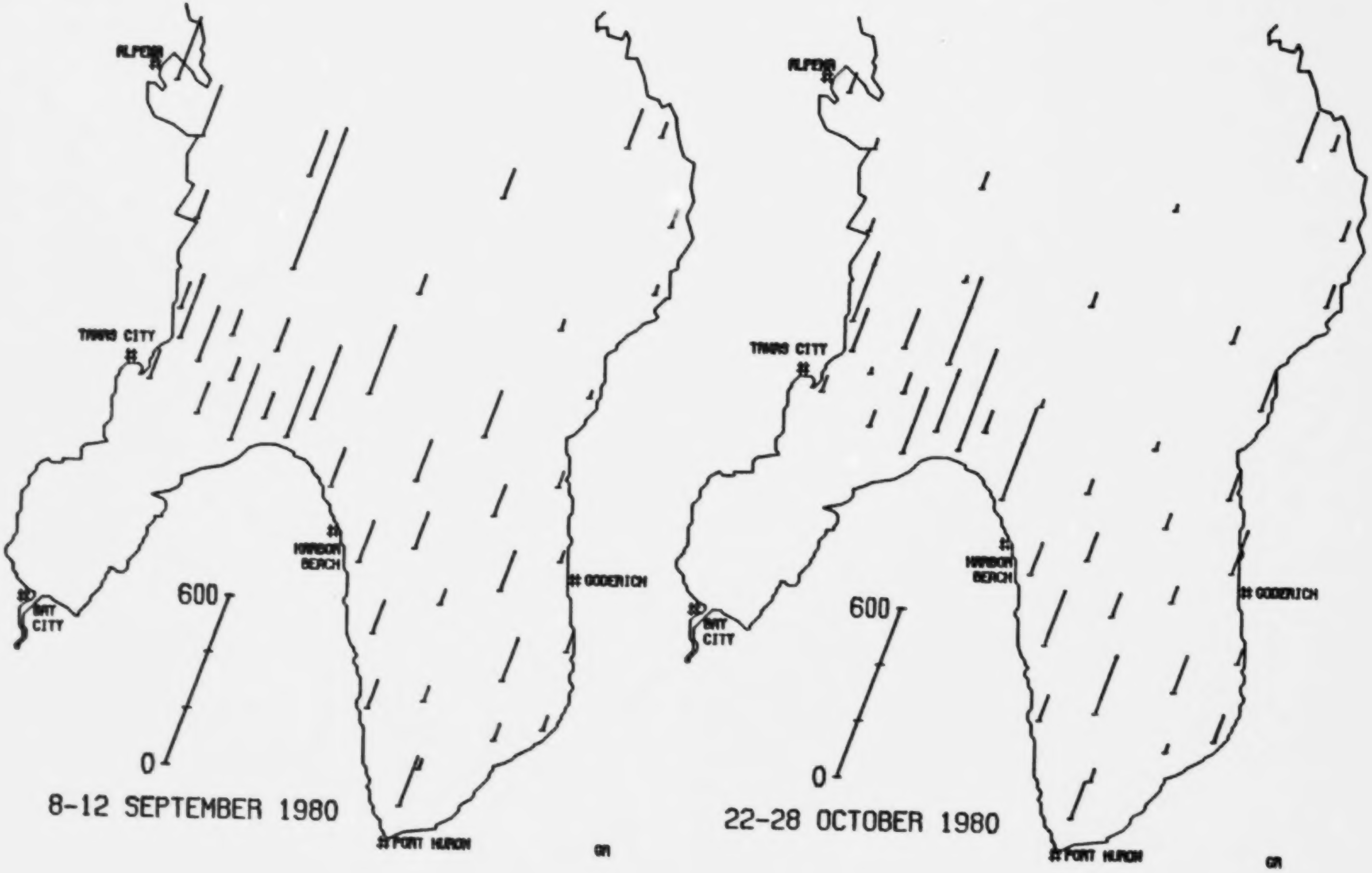
Figure 36. Seasonal distribution and abundance trends of Green algae.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GR
0
600
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GR
0
600

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 36. (continued)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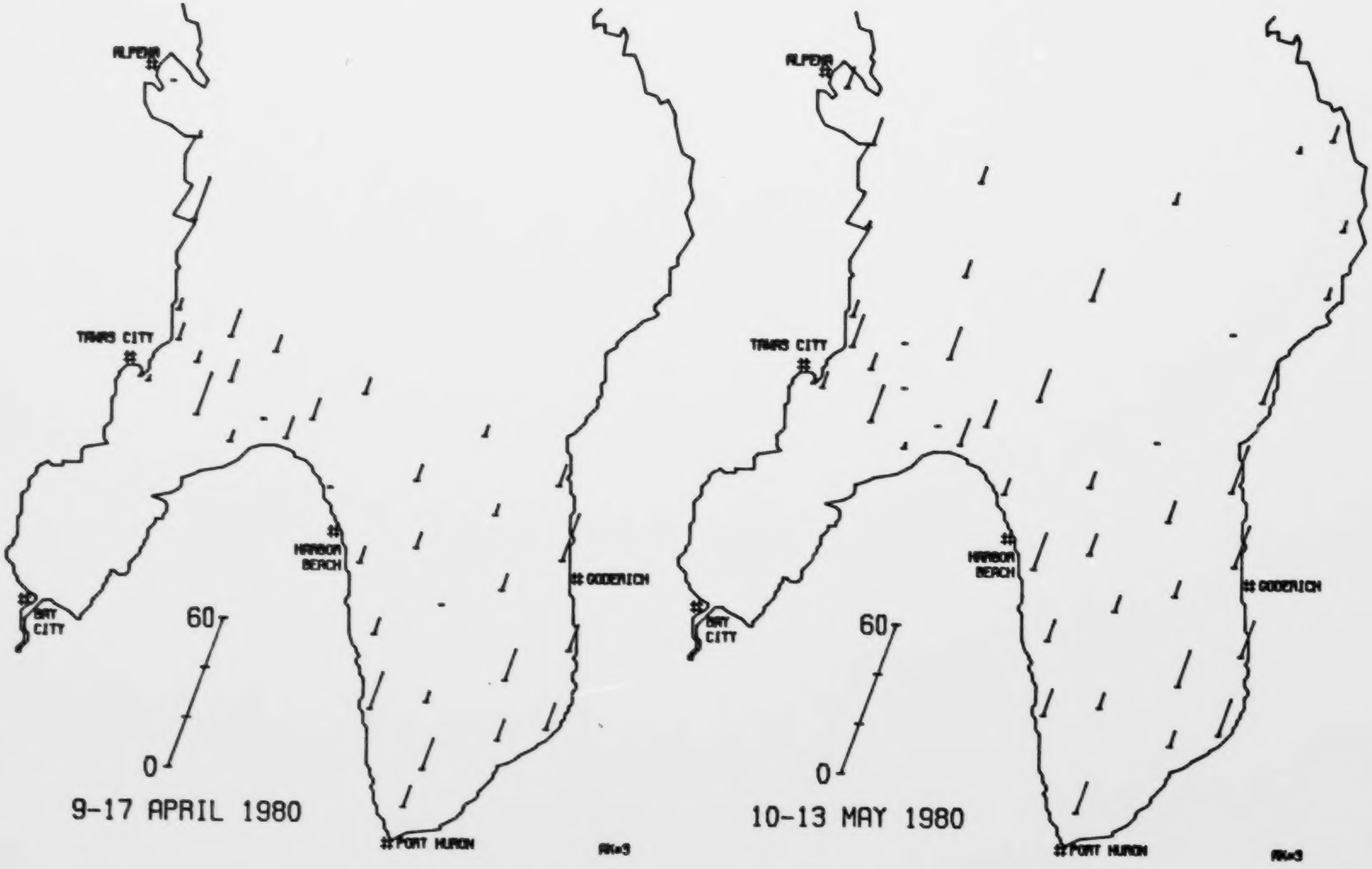
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GR
600
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 36. (continued)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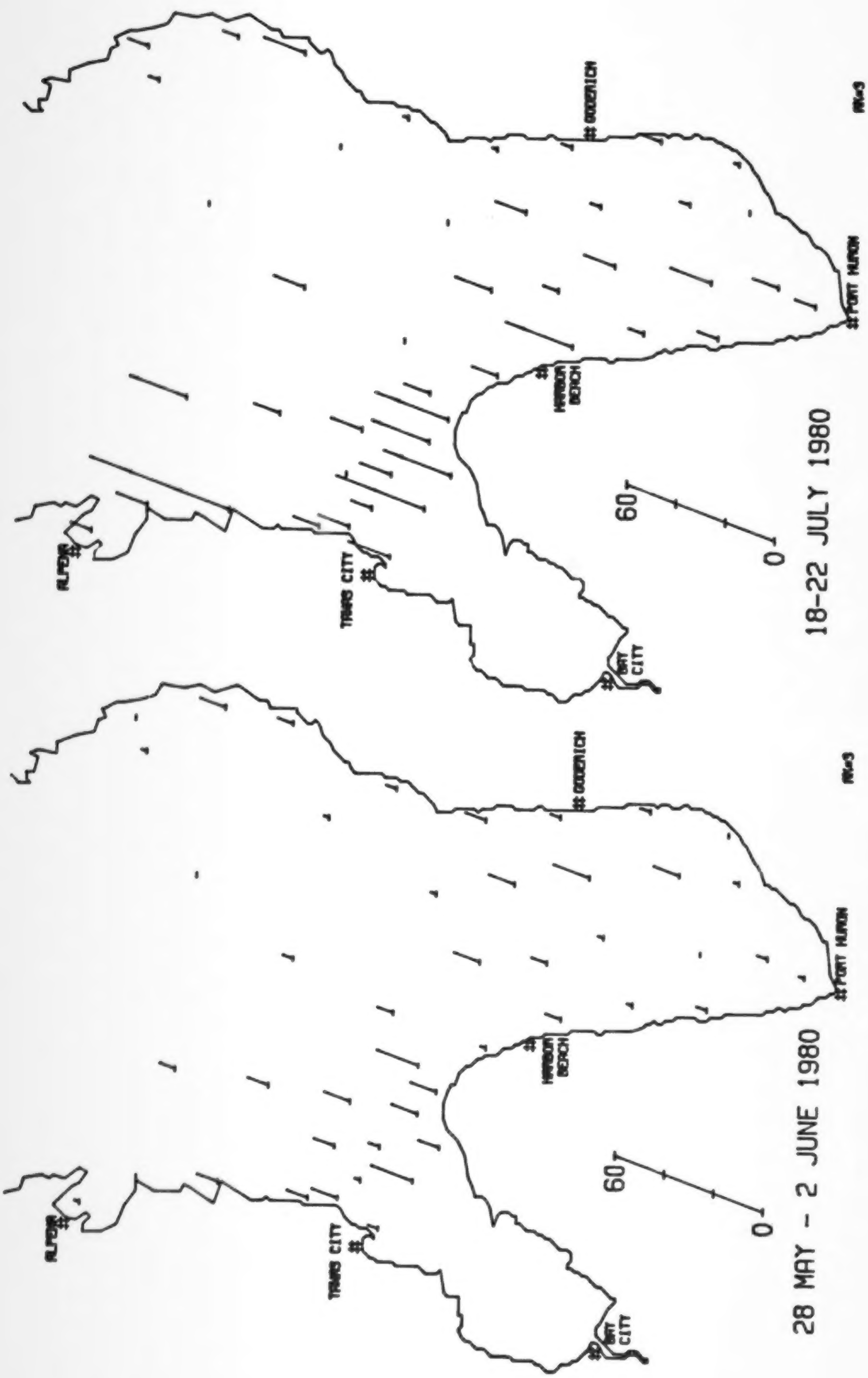
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
9-17 APRIL 1980
AK#3
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
10-13 MAY 1980
AK#3

Figure 37. Distribution of Ankistrodesmus sp. #3.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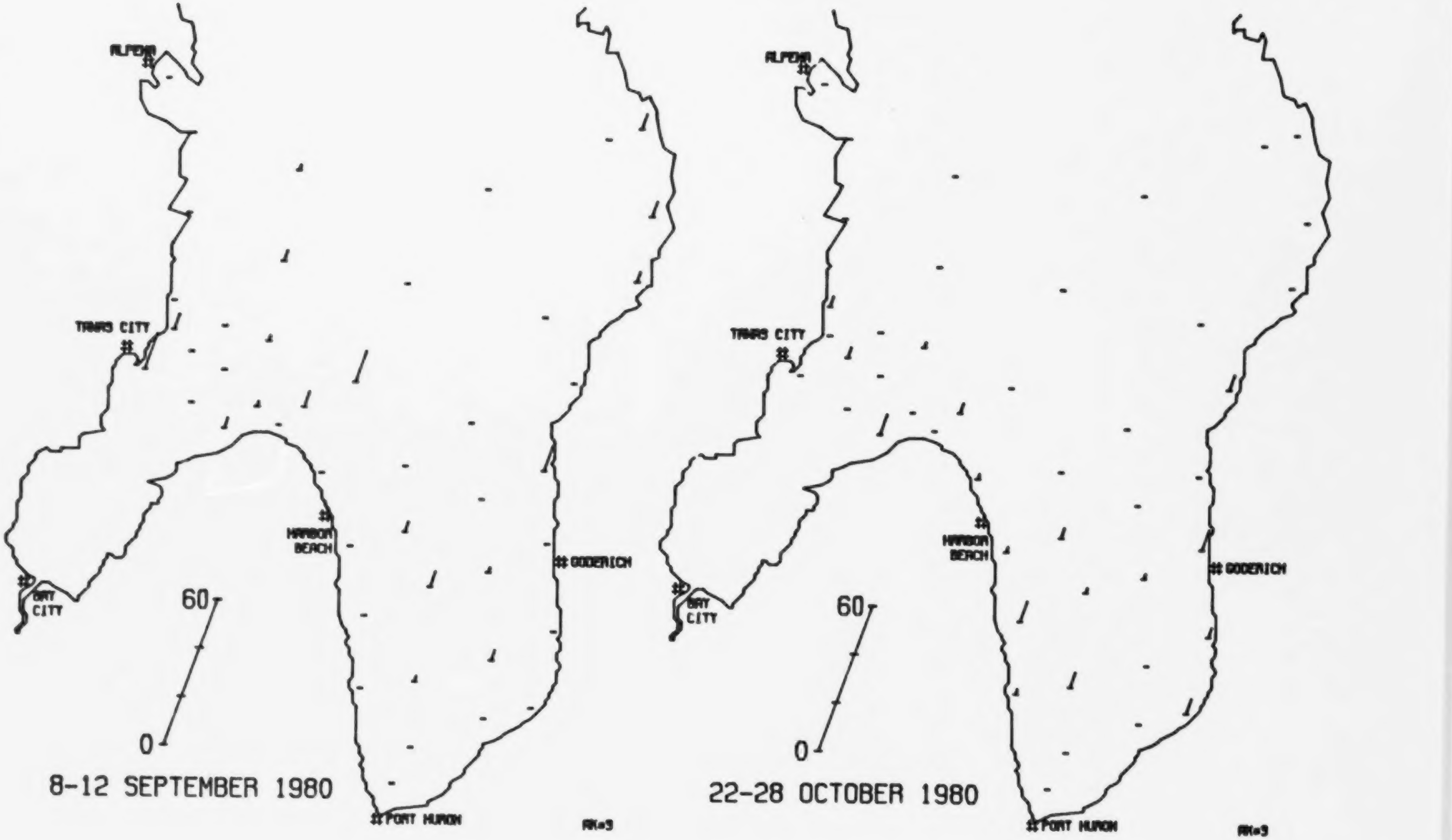
TRAVS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
RN=3
60
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 37. (continued)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TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
60
0
RK=3
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
60
0
RK=3

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

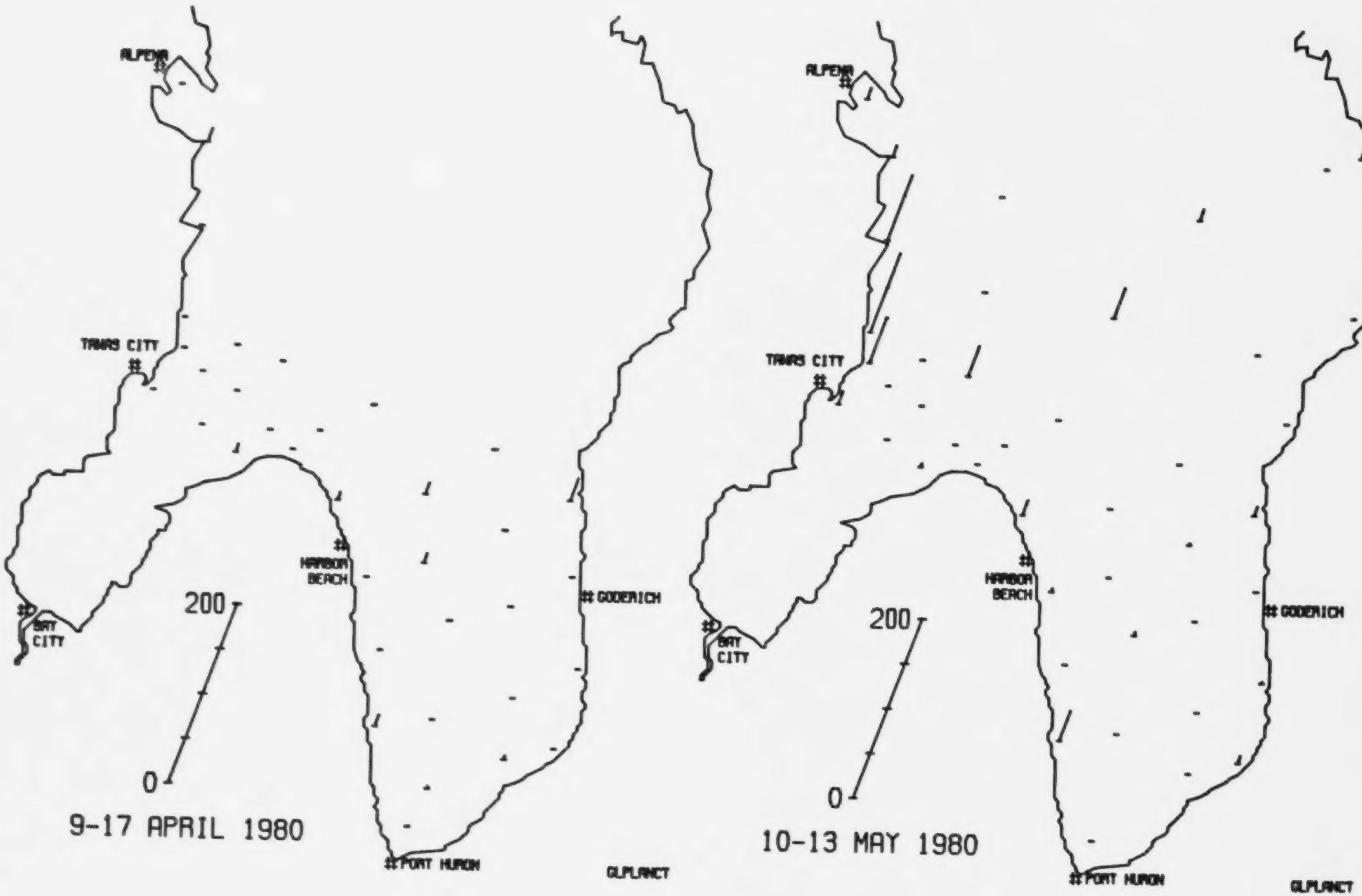
Figure 37. (continued)

Gloeocystis planctonica

G. planctonica is commonly reported from the Great Lakes and inland lakes of the Great Lakes states (Prescott 1962). It appears to reach its greatest abundance in enriched areas of the Great Lakes. During April (fig. 38A) abundance was very low showing no distributional patterns. Abundance in May (fig. 38B) was slightly elevated from the previous month with greatest abundance north of Tawas City in the nearshore zone. In June (fig. 38C) this species showed a wider distribution especially in the southern basin with highest abundances near Saginaw Bay. During July (fig. 38D) large peaks were observed south of Alpena however with numerous occurrences near Saginaw Bay. Greatest abundance for the season was recorded in September (fig. 38E). Large abundances were seen in the Saginaw Bay interface, at Alpena and Port Huron however distribution was erratic. In October (fig. 38F) abundance was greatly reduced, however it was distributed throughout the study area excepting the northeastern sector.

Green filament sp. #5

Due to its small diameter (approximately 2um) and varying internal cell structure, this filamentous alga has not been placed in a formal taxonomic category. It was previously observed in southern Lake Huron in 1974 (Stoermer and Kreis 1980). In April (fig. 39A) highest abundance was noted in the offshore area of the southern basin. During May (fig. 39B) it was absent from the open waters of the



9-17 APRIL 1980

10-13 MAY 1980

ALPENA
TRVRS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GLPLANCT
200
0
ALPENA
TRVRS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GLPLANCT
200
0

Figure 38. Distribution of Gloeocystis planctonica.

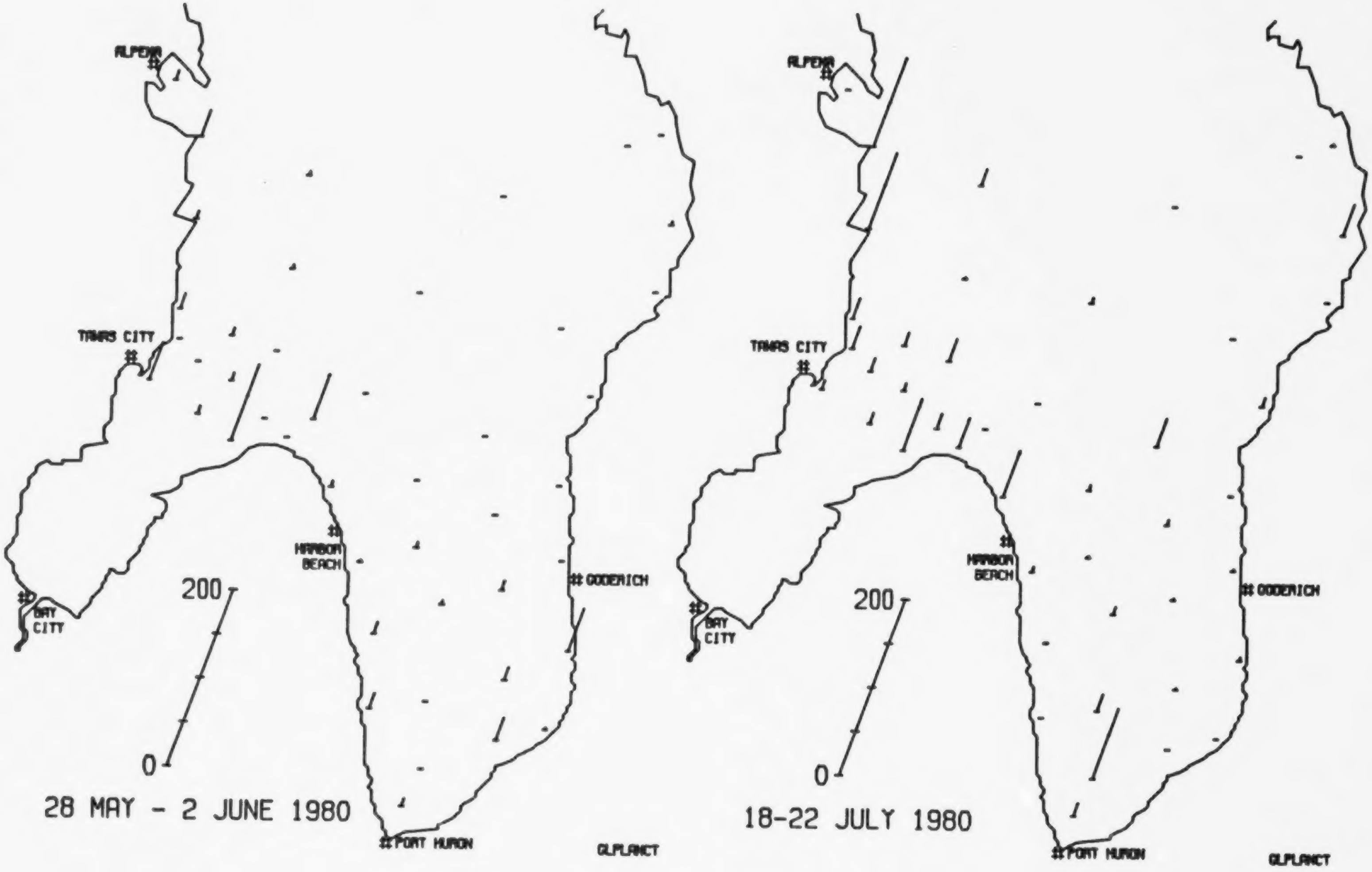
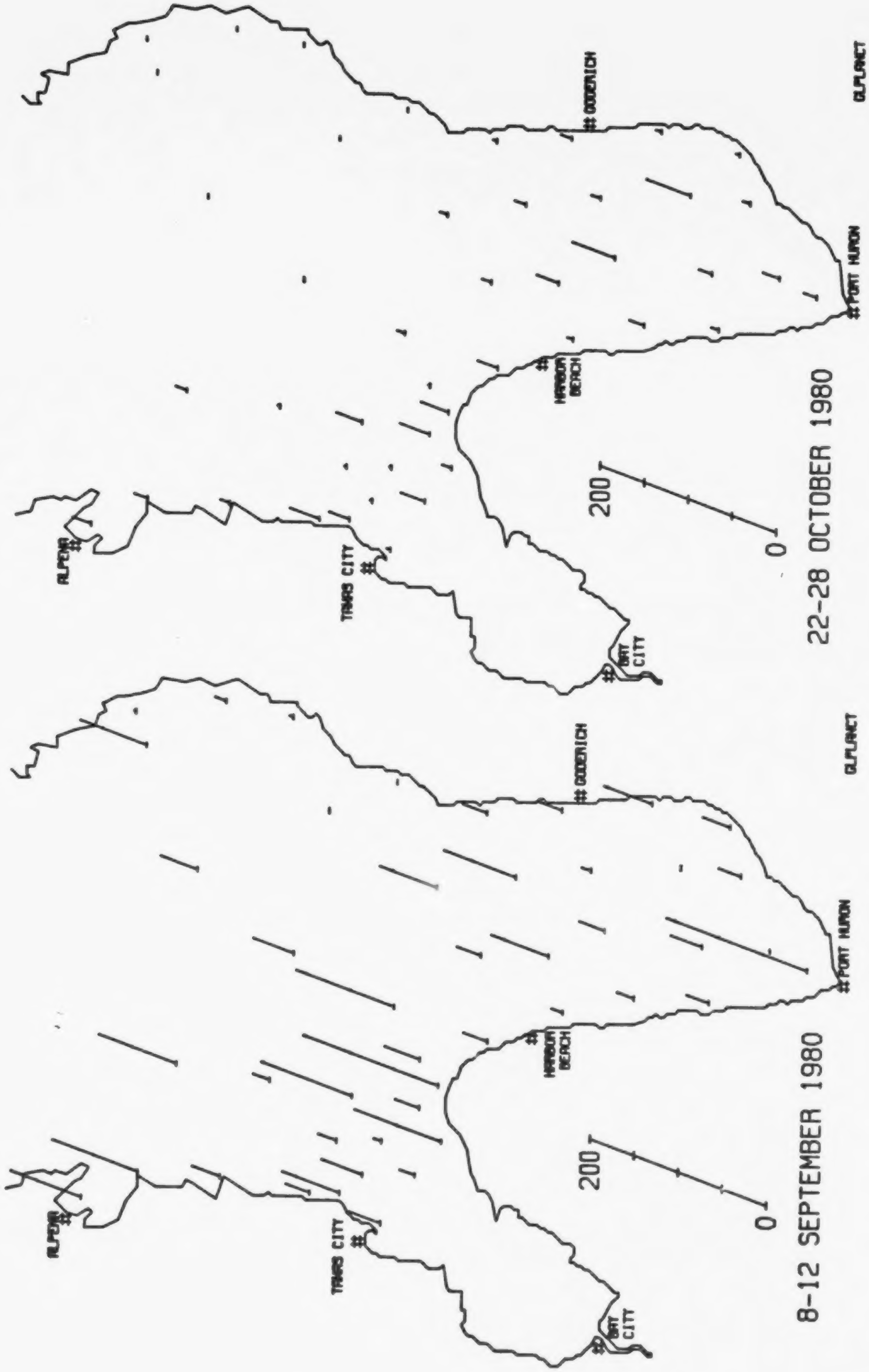

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
200
0
28 MAY - 2 JUNE 1980
GLPLANCT
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
200
0
18-22 JULY 1980
GLPLANCT

Figure 38. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GLFLMCT
200
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
GLFLMCT
200
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 38. (continued)

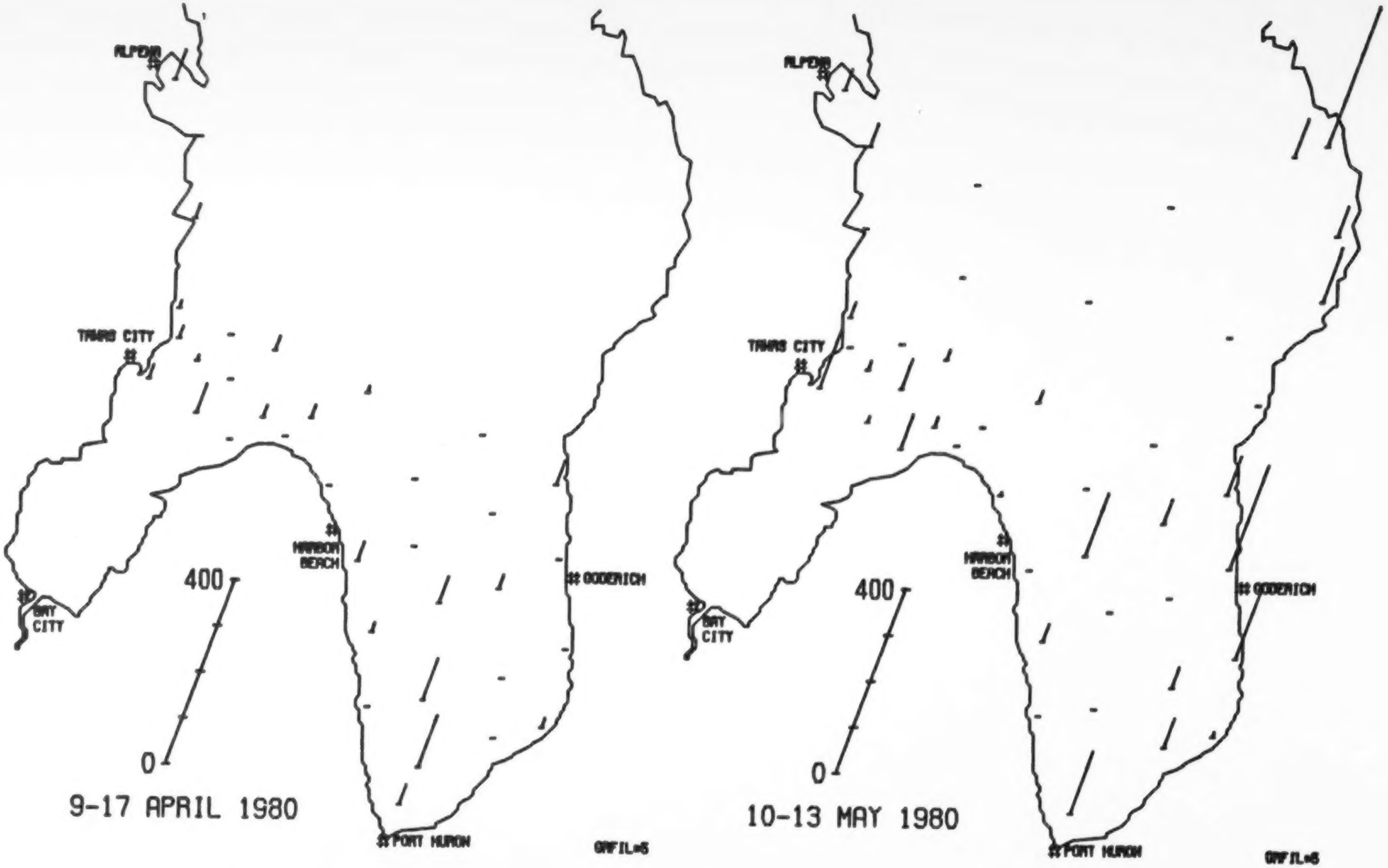
central basin but had highest abundances in the Canadian nearshore zone. In June (fig. 39C) it was widely distributed throughout the study area in no apparent pattern. From July through October (figs. 39D-39F) very low abundances were recorded, usually from the central basin.

Scenedesmus quadricauda

This colonial green alga is commonly reported from the plankton of small inland lakes. It is one of the most frequently reported species of this genus from the Great Lakes. As most green algae in the Great Lakes, it reaches its greatest abundance during the summer in enriched areas. In April (fig. 40A) greatest abundance was observed in outer Saginaw Bay with several sporadic occurrences in the southern basin. During May (fig. 40B) again, highest cell numbers were observed in outer Saginaw Bay and just south of the bay. Occurrences were restricted to the U.S. nearshore zone of the southern basin. Sporadic occurrences at low abundance were seen along the entire U.S. shoreline in June through September (figs. 40C - 40E). During October (fig. 40F) it reached its greatest abundance in outer Saginaw Bay and south of the bay. Occurrences were also observed between Alpena and Tawas City and in the Canadian nearshore zone of the southern basin.

CYANOPHYTA - BLUE-GREENS

Massive water blooms of blue-green algae are generally considered to be indicative of eutrophic conditions (Hutchinson 1967). For the Great Lakes this assumption is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TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
9-17 APRIL 1980
GRFIL=5
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
10-13 MAY 1980
GRFIL=5

Figure 39. Distribution of Green filament sp. #5.

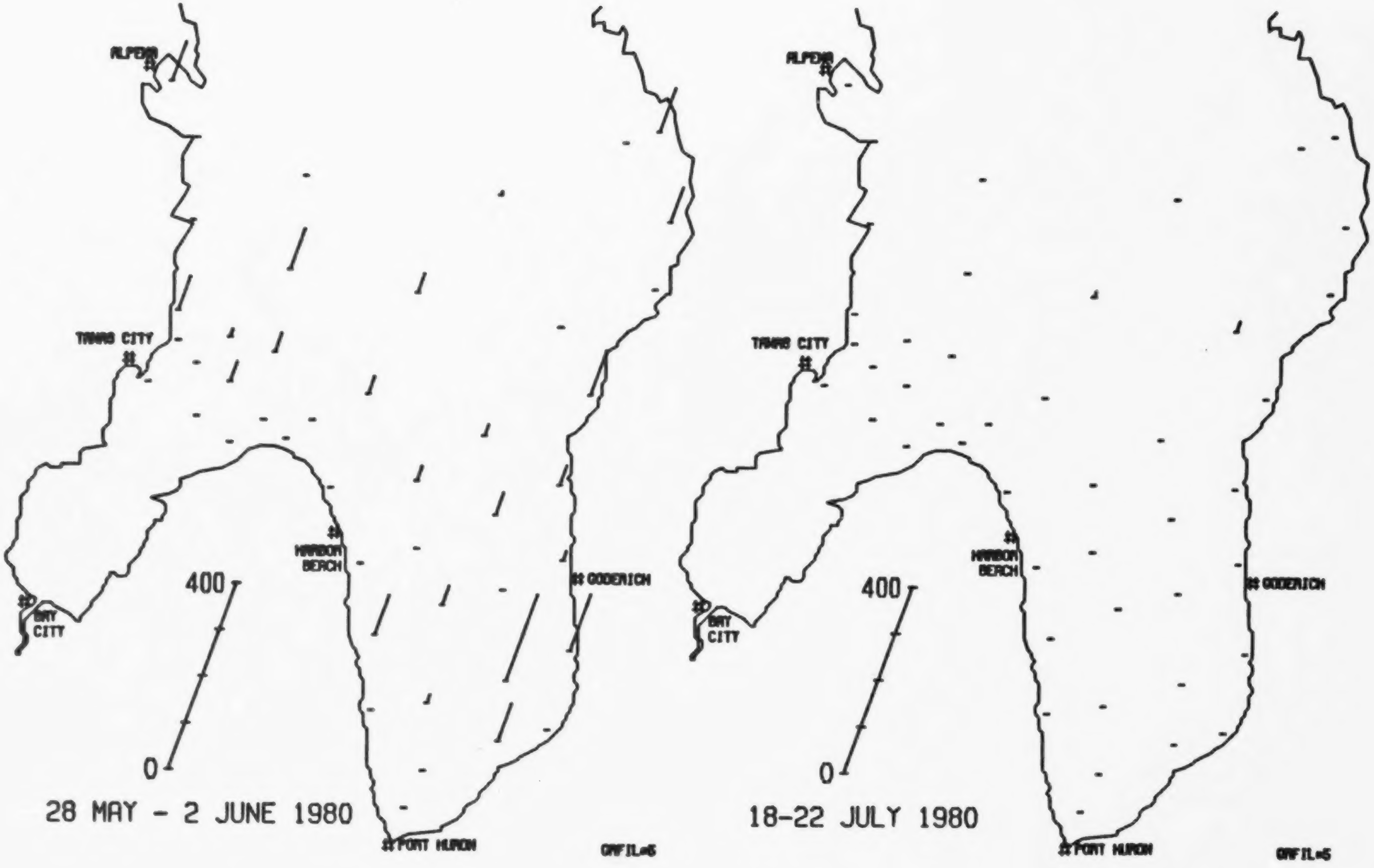
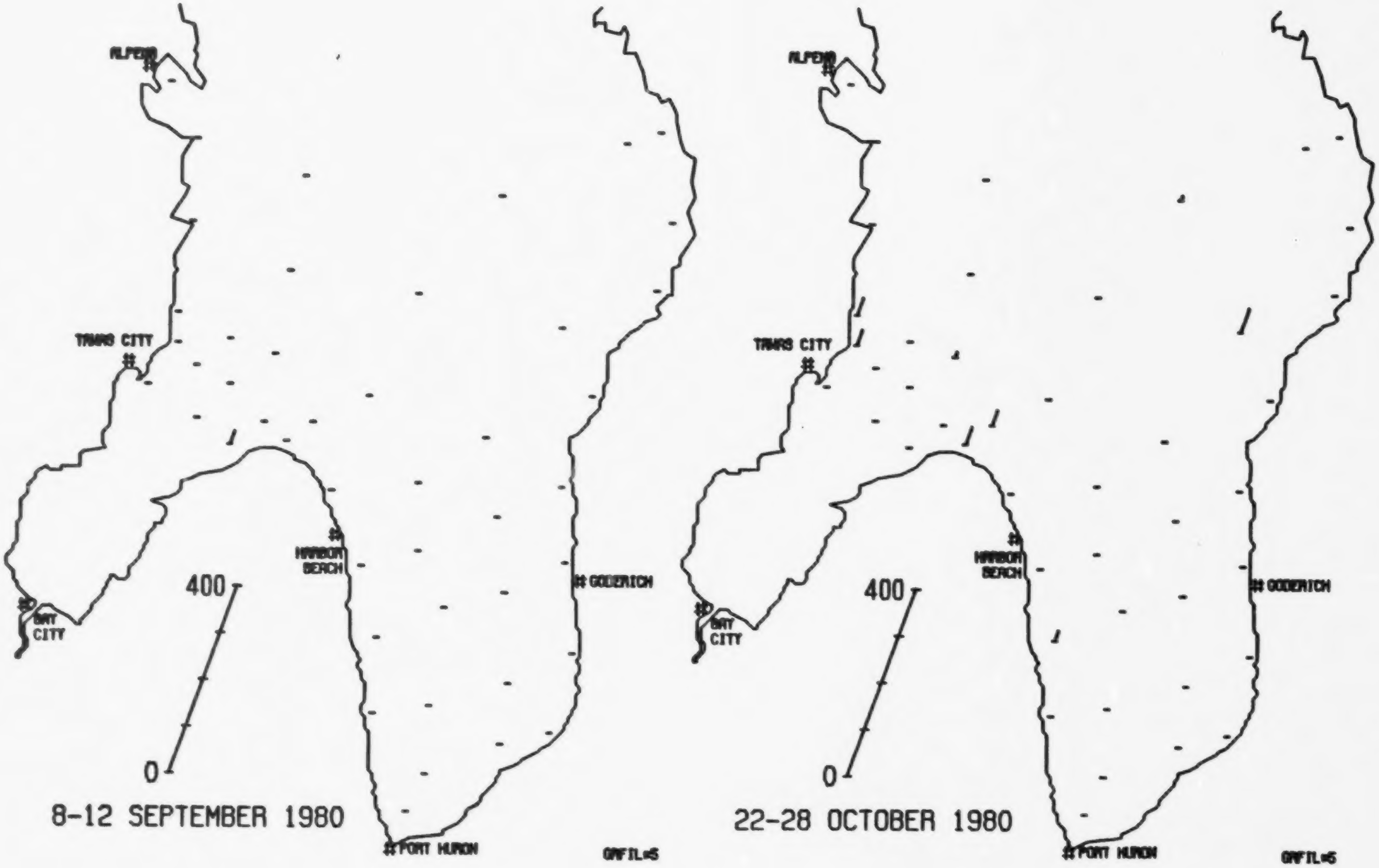

ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
400
0
28 MAY - 2 JUNE 1980
GRFIL=5
ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
400
0
18-22 JULY 1980
GRFIL=5

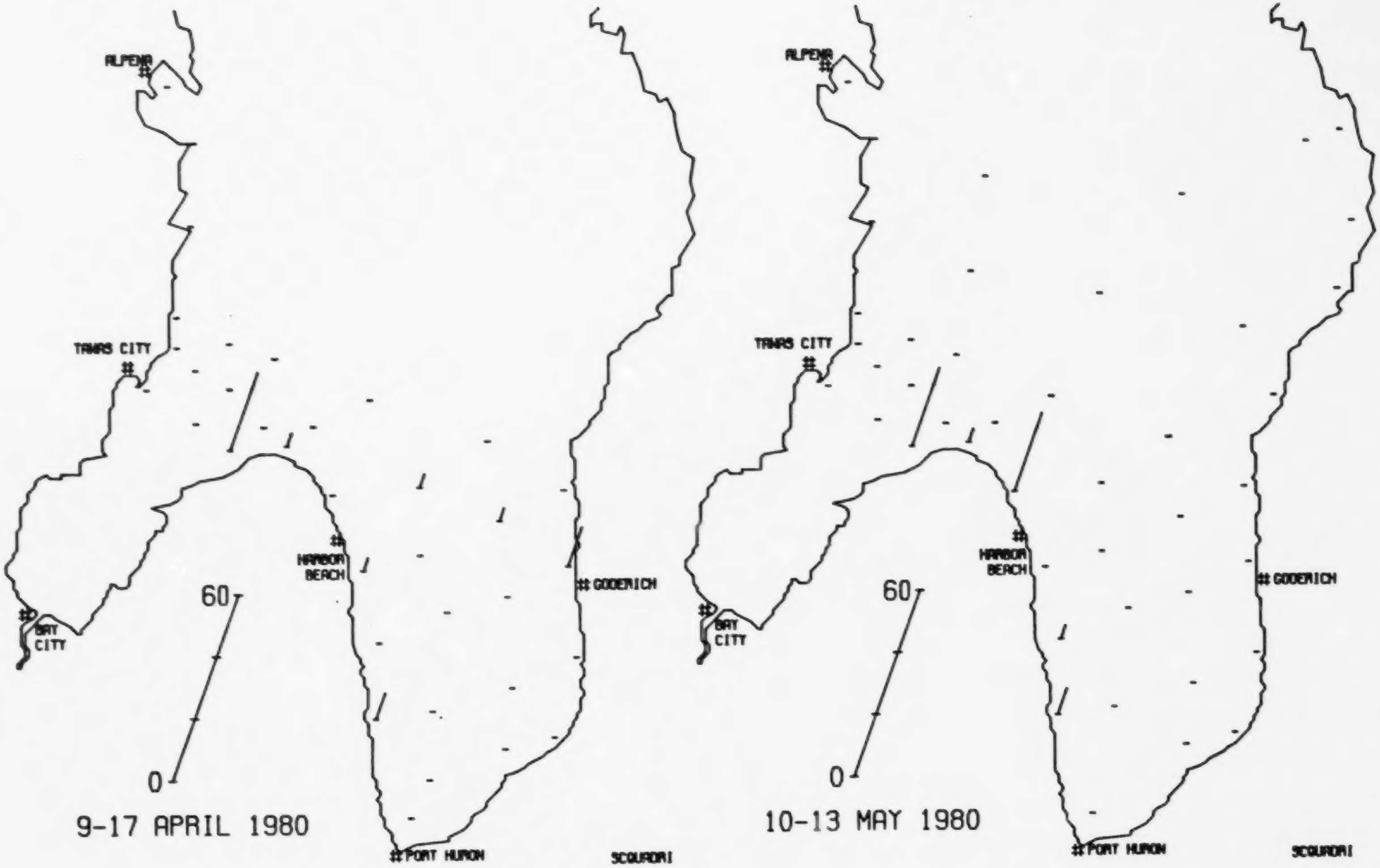
Figure 39. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
400
0
GAFIL=5
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
400
0
GAFIL=5

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

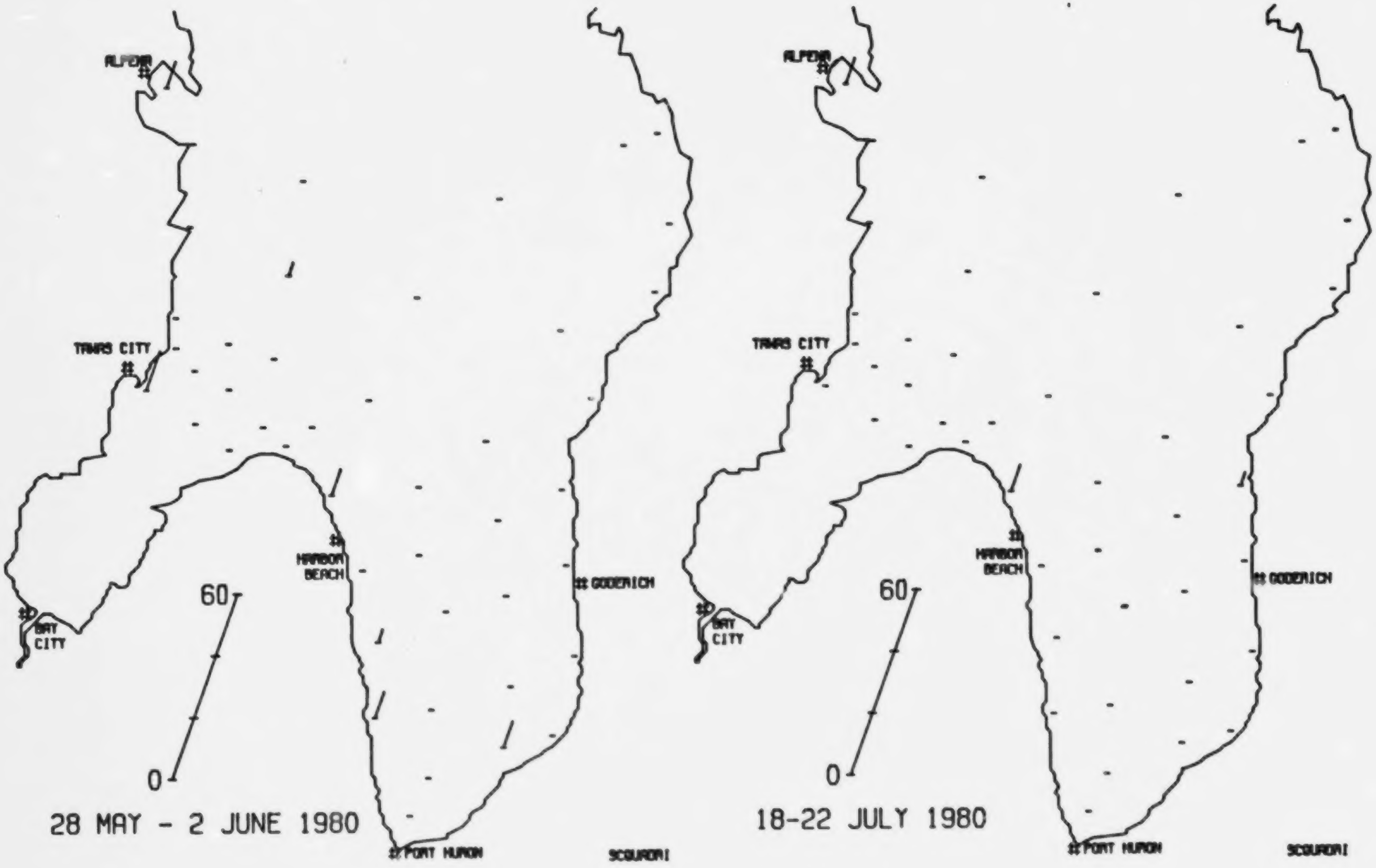
Figure 39. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
60
0
GODERICH
PORT HURON
SCQUADRI

9-17 APRIL 1980

10-13 MAY 1980

Figure 40. Distribution of Scenedesmus quadricauda.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SCOURAI
60
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 40. (continued)

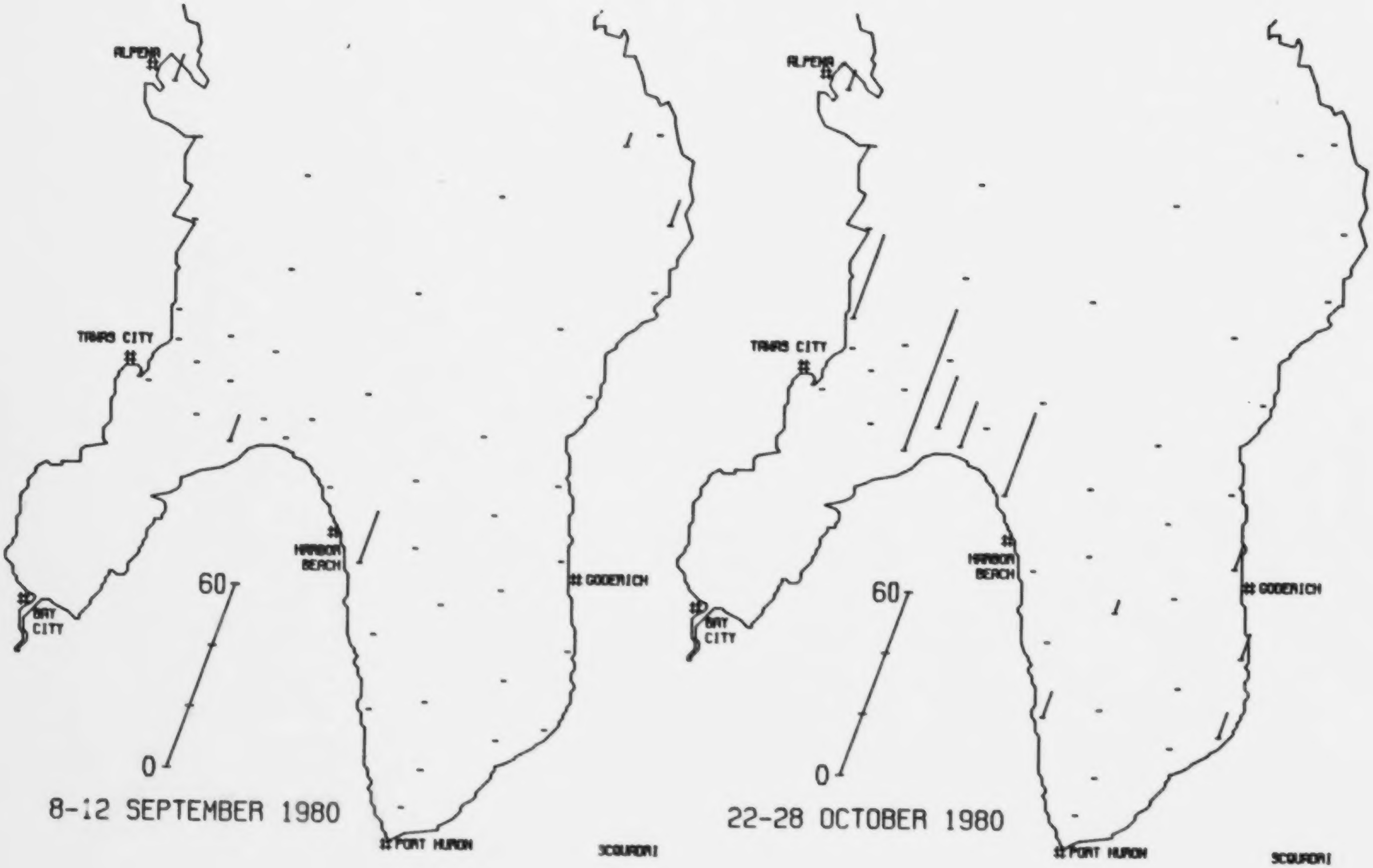

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SCOURDRI
60
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SCOURDRI
60
0
22-28 OCTOBER 1980

Figure 40. (continued)

generally correct with high blue-green abundances reported in Saginaw Bay (Stoermer _et_ _al_. 1982), Green Bay (Stoermer and Stevenson 1979) and the western end of Lake Erie (Munawar and Munawar 1976). However, the situation is complicated in the upper Great Lakes by the occurrence, sometimes in substantial abundances, of blue-greens which find their primary habitat in the offshore plankton during the silicate-limited period in the fall. This particular case demonstrates the need for taxonomic identification to the species level in order to properly assess trophic conditions. During this study, both colonial and filamentous forms were observed in southern Lake Huron, however most species present are not associated with eutrophic conditions. Quantitative estimates of blue-green algae are sometimes misleading due to their colonial and filamentous habit, as well as their tendency to bloom, creating a patchy distribution.

From April through June (figs. 41A - 41C), the blue-green algae were widely distributed over the study area in uniformly low abundances. Greatly reduced occurrences and abundances were observed in July (fig. 41D). July values were the lowest seasonal values recorded. During September (fig.41E) blue-greens dramatically increased in abundance and this period included the highest single and average values for the season. Greatest abundance was observed in the Saginaw Bay interface and waters just south of the bay. Large abundances were also observed in Thunder Bay and the nearshore zone south of Alpena. Comparatively lesser amounts of blue-greens occurred in the eastern half of the lake, particularly in the Canadian coastal zone. Abundances were slightly less in October (fig. 41F) but remained relatively high. Abundances were more uniformly distributed, however very low values were again observed for the entire Canadian nearshore zone.

Anabaena flos-aquae

This blue-green alga usually reaches its greatest abundance in areas of the Great Lakes which have been eutrophied. It is the only blue-green species reported which is usually associated with enriched conditions. A. flos-aquae may form conspicuous waters blooms and is commonly noted in summer plankton of inland lakes of the Great Lakes states (Prescott 1962). It is also the only heterocystaceous blue-green reported in this study. Its filaments occur in large, entangled masses and due to the presence of heterocysts and pseudovacuoles are usually seen in highest concentrations in the upper waters of the epilimnion. In this study, A. flos-aquae was not observed until July where it was recorded in low abundances in Thunder Bay and south of Goderich (fig. 42A). It was observed in Thunder Bay again, in the mid-southern basin and the northeast section of the study area in September (fig. 42B). It reached it greatest abundance at Tawas City in October (fig. 42C) and was also observed on the northern Canadian coast.

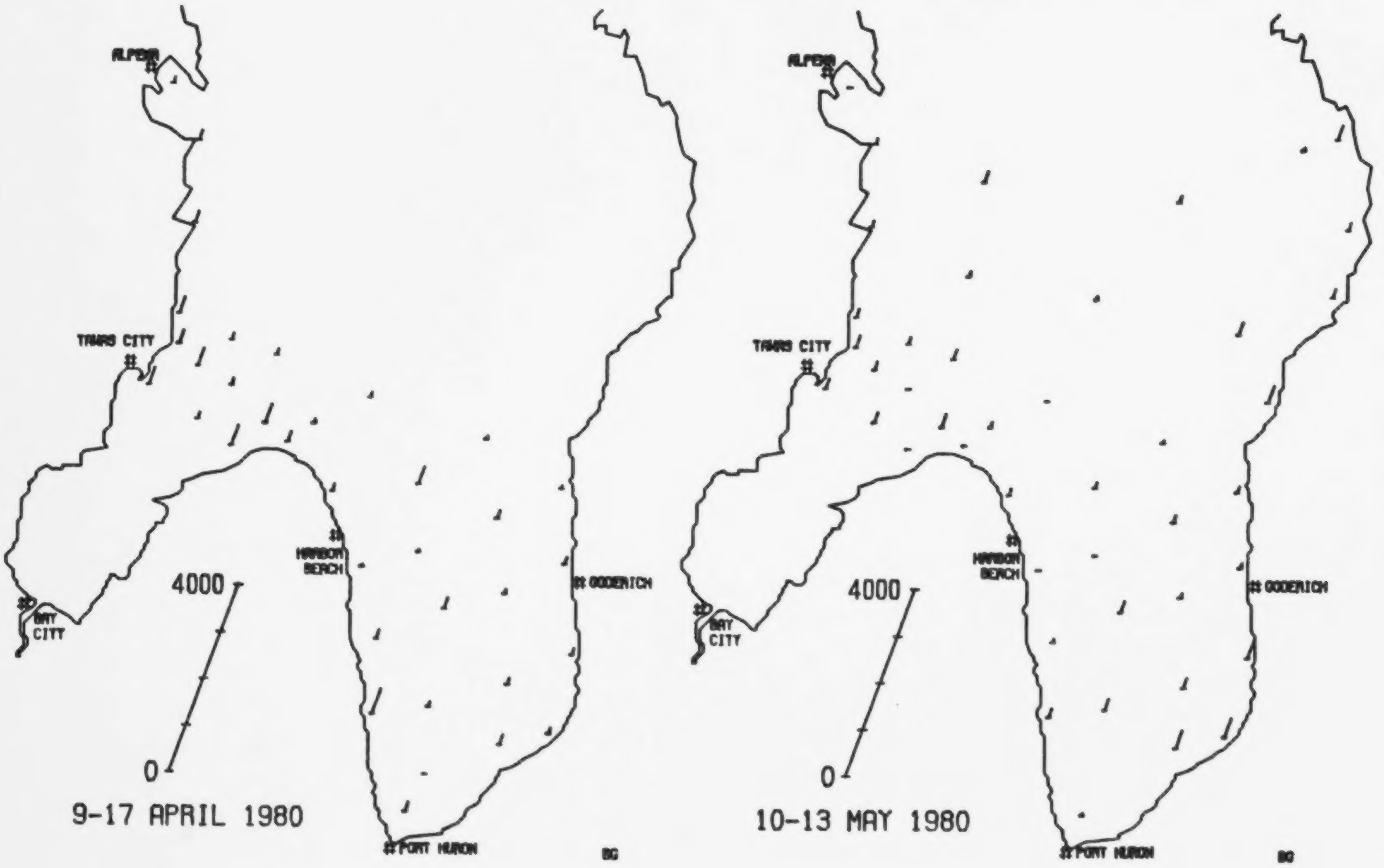
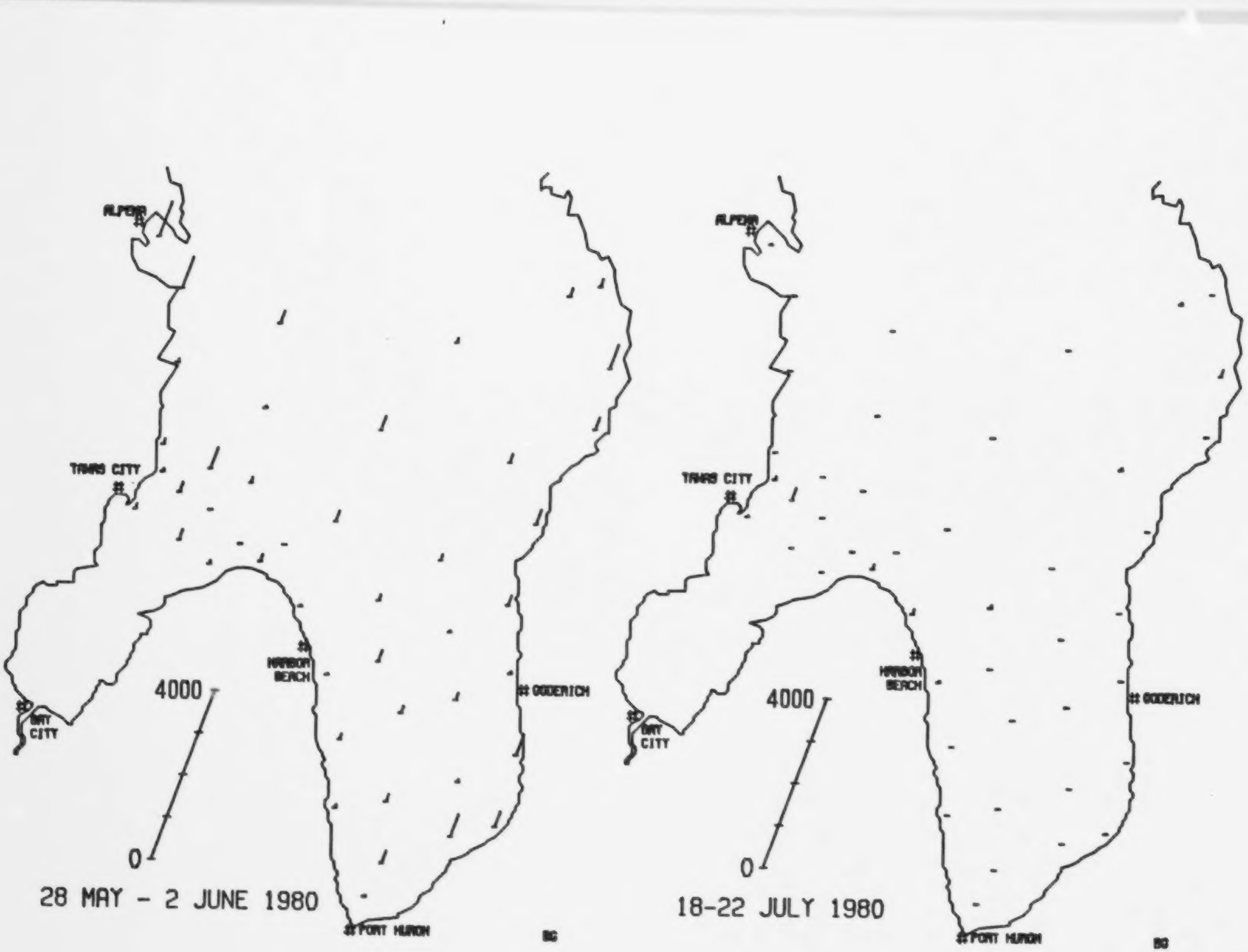

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
BG
4000
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
BG
4000
0
10-13 MAY 1980

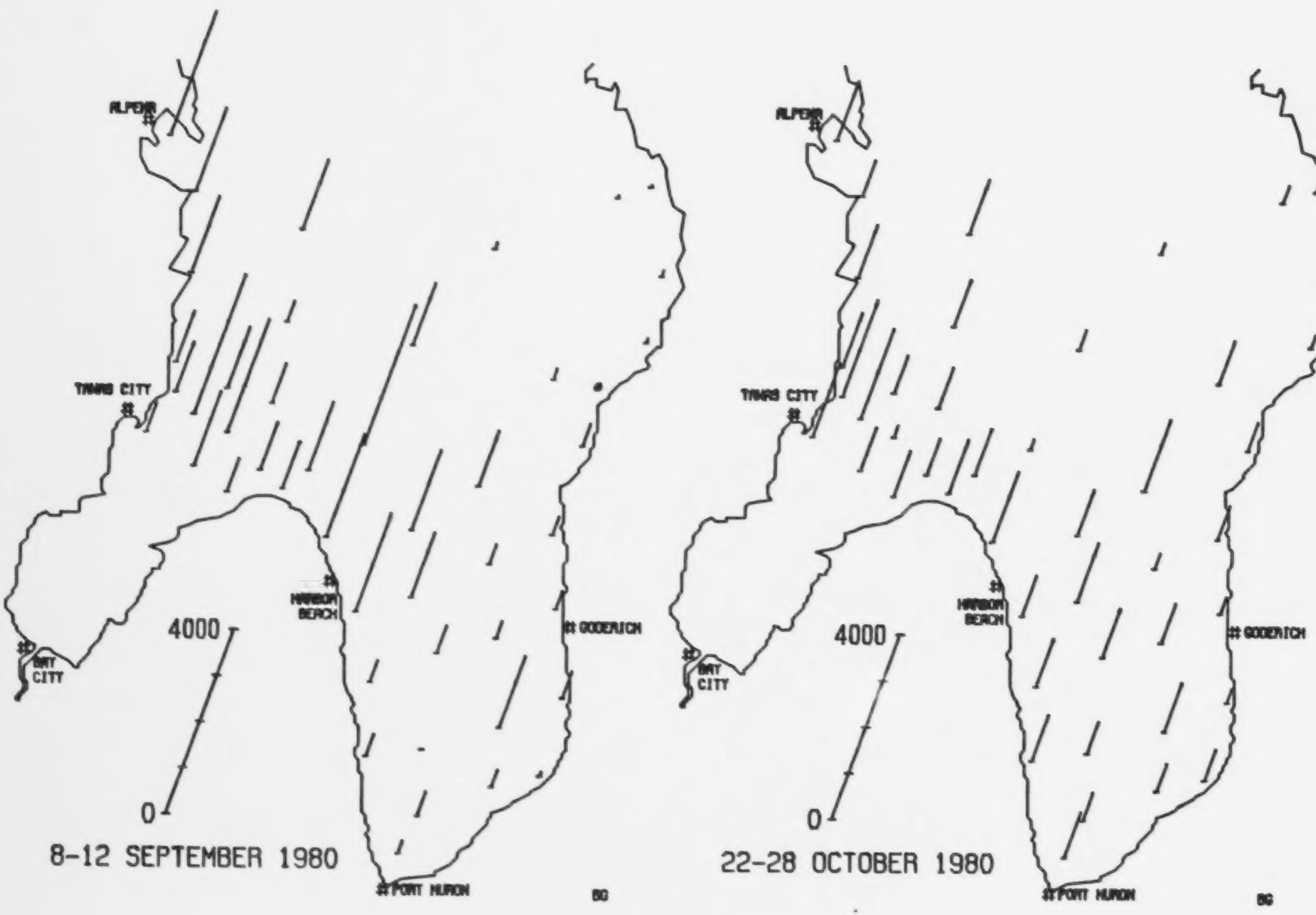
Figure 41. Seasonal distribution and abundance trends of Blue-Green algae.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
BG
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
BG

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 41. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
BG
4000
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
BG
4000
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 41. (continued)

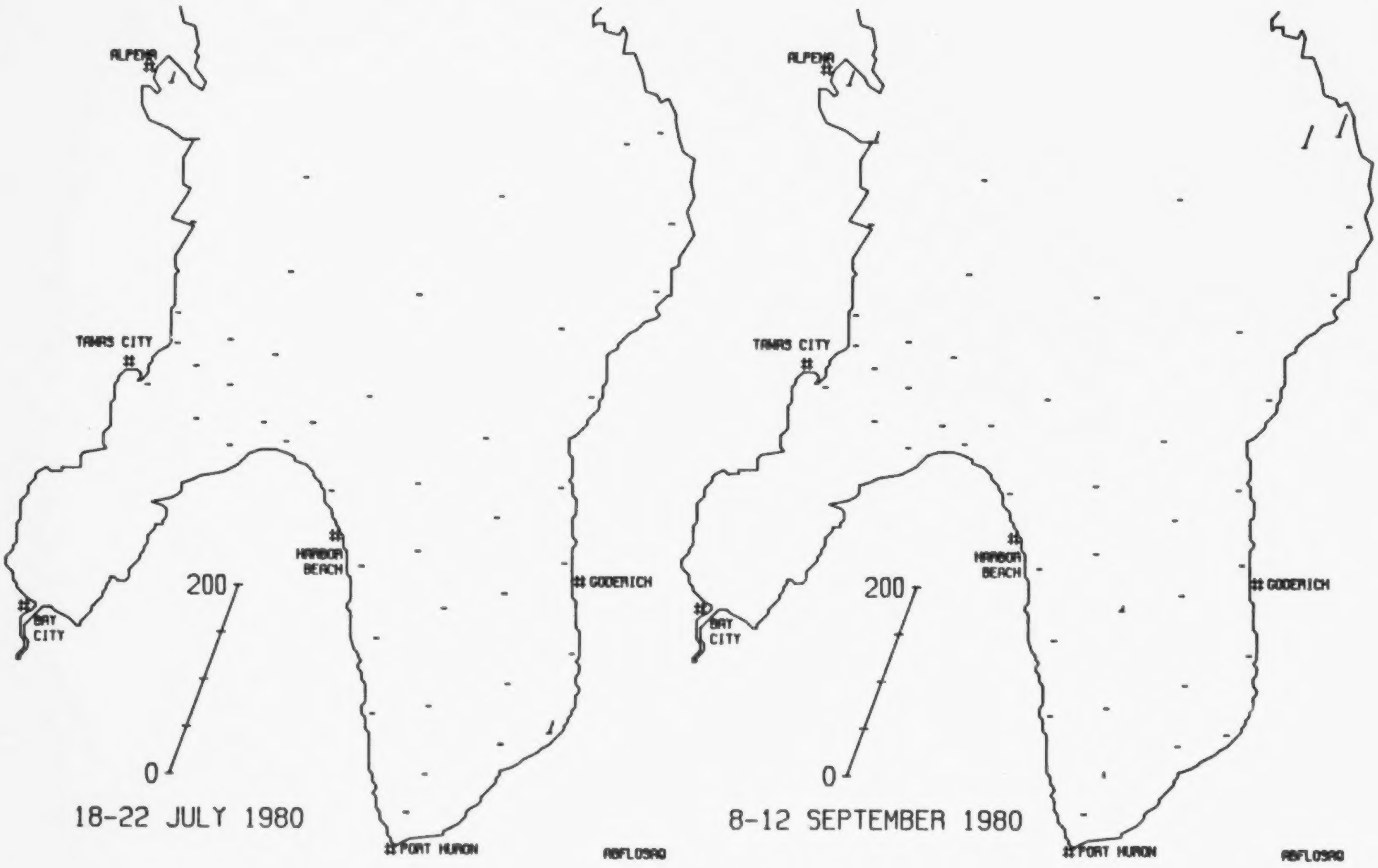

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
200
0
18-22 JULY 1980
ABFLOSAQ
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
200
0
8-12 SEPTEMBER 1980
ABFLOSAQ

Figure 42. Distribution of Anabaena flos-aquae.

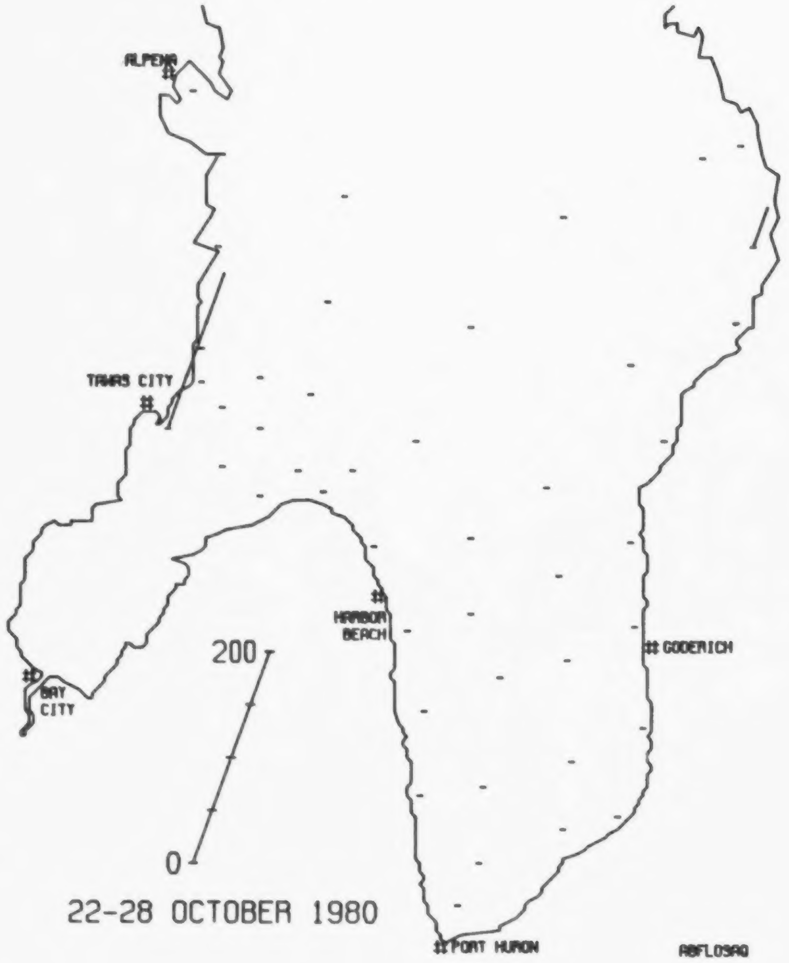

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
200
0
22-28 OCTOBER 1980
ABFLOSAQ

Figure 42. (continued)

Anacystis incerta

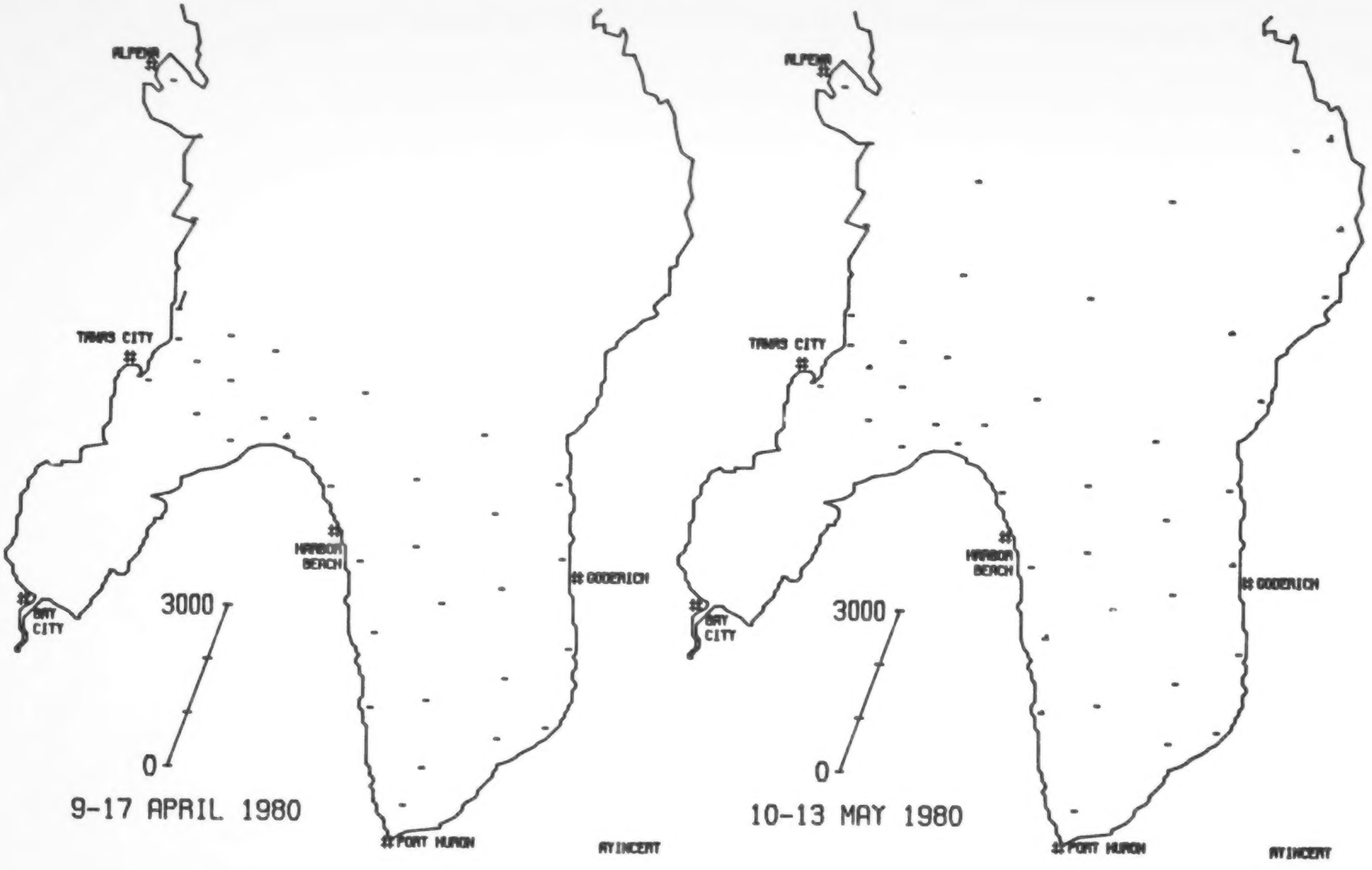
This taxon is commonly observed in the offshore waters of the upper Great Lakes during the fall. During this study, it reached its greatest abundance in the fall and was, on average, the most abundant blue-green alga. A. incerta occurs in colonial form, generally with 100-500 individuals enclosed in a muscilaginous matrix. From April through July (figs. 43A - 43D) abundances were very low showing sproadic occurrences. Populations reached greatest abundance in September (fig. 43E) especially in the Saginaw Bay interface waters and in the upper sector of the southern basin. Reduced cell numbers and an erratic distribution were observed in October (fig. 43F).

Anacystis thermalis

As the other member of this genus just discussed, this taxon exhibits highest abundance during the fall months. However A. thermalis usually occurs in small colonies of 4 to 8 individuals. From April through July, (figs. 44A - 44D) this species showed very low abundances and no apparent distributional pattern. It reached its greatest abundance in September (fig. 44E) in the Saginaw Bay interface waters and in the northern basin, paticularly in the U.S. sector. In October, (fig. 44F) abundances were reduced and fairly uniformly distributed over the study area.

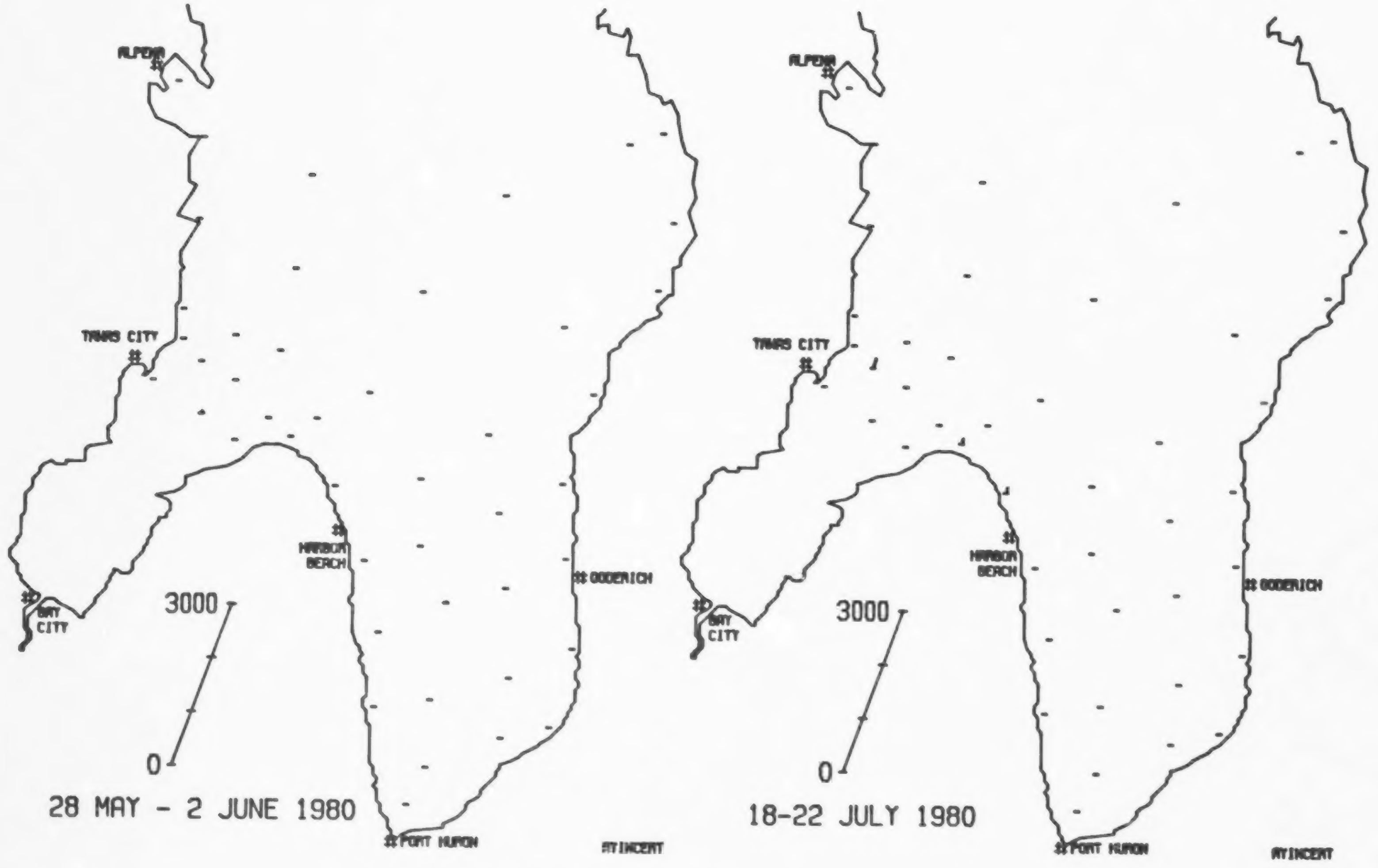
Gomphosphaeria lacustris

This colonial blue-green is commonly observed during the late summer and fall in the upper Great Lakes. It



ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
PT INCENT
3000
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
PT INCENT
3000
0
10-13 MAY 1980

Figure 43. Distribution of Anacystis incerta.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
PT VINCENT
3000
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 43. (continued)

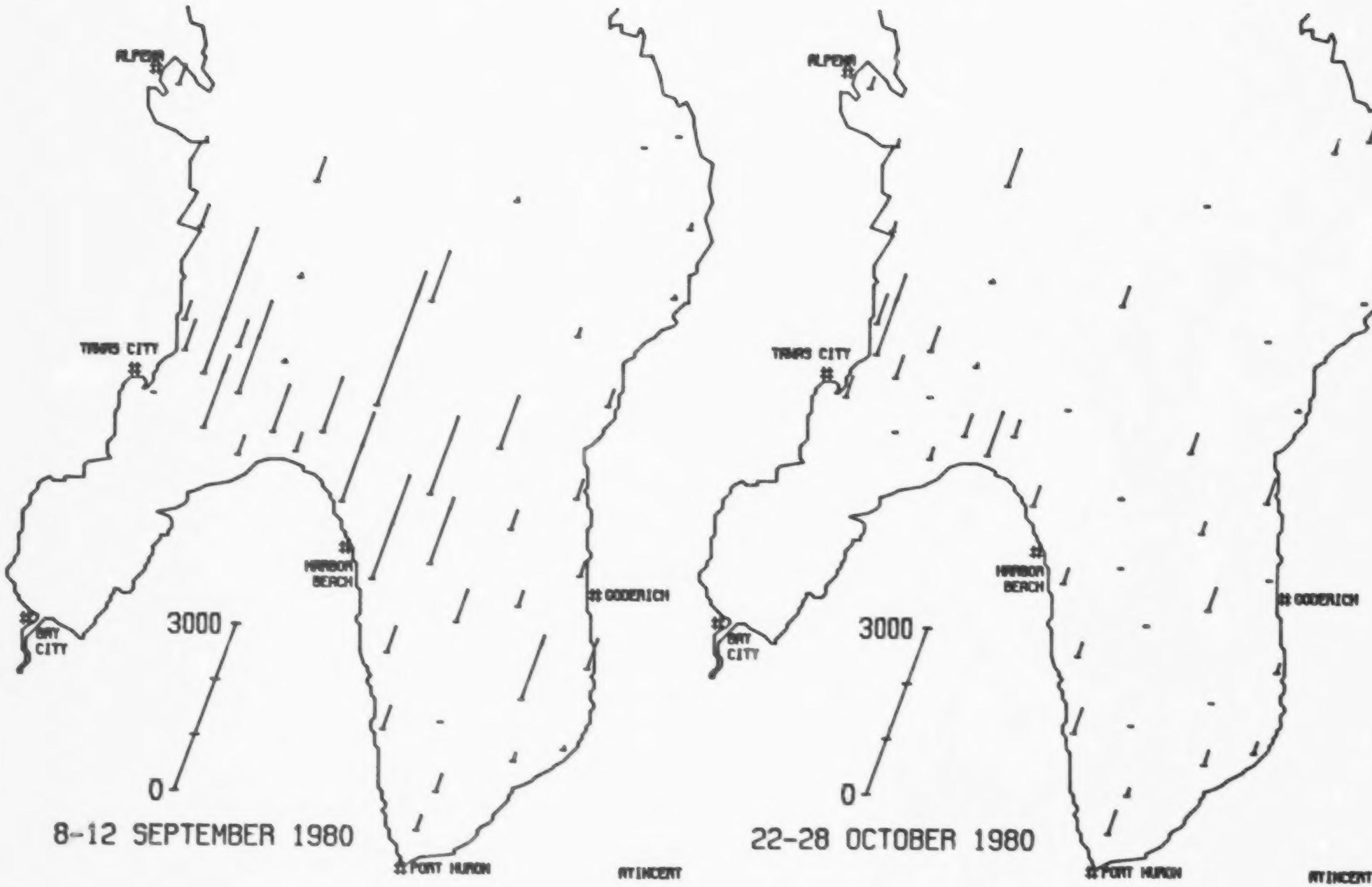

ALPENA
TRAVS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
RT.INCENT
3000
0
8-12 SEPTEMBER 1980
22-28 OCTOBER 1980

Figure 43. (continued)

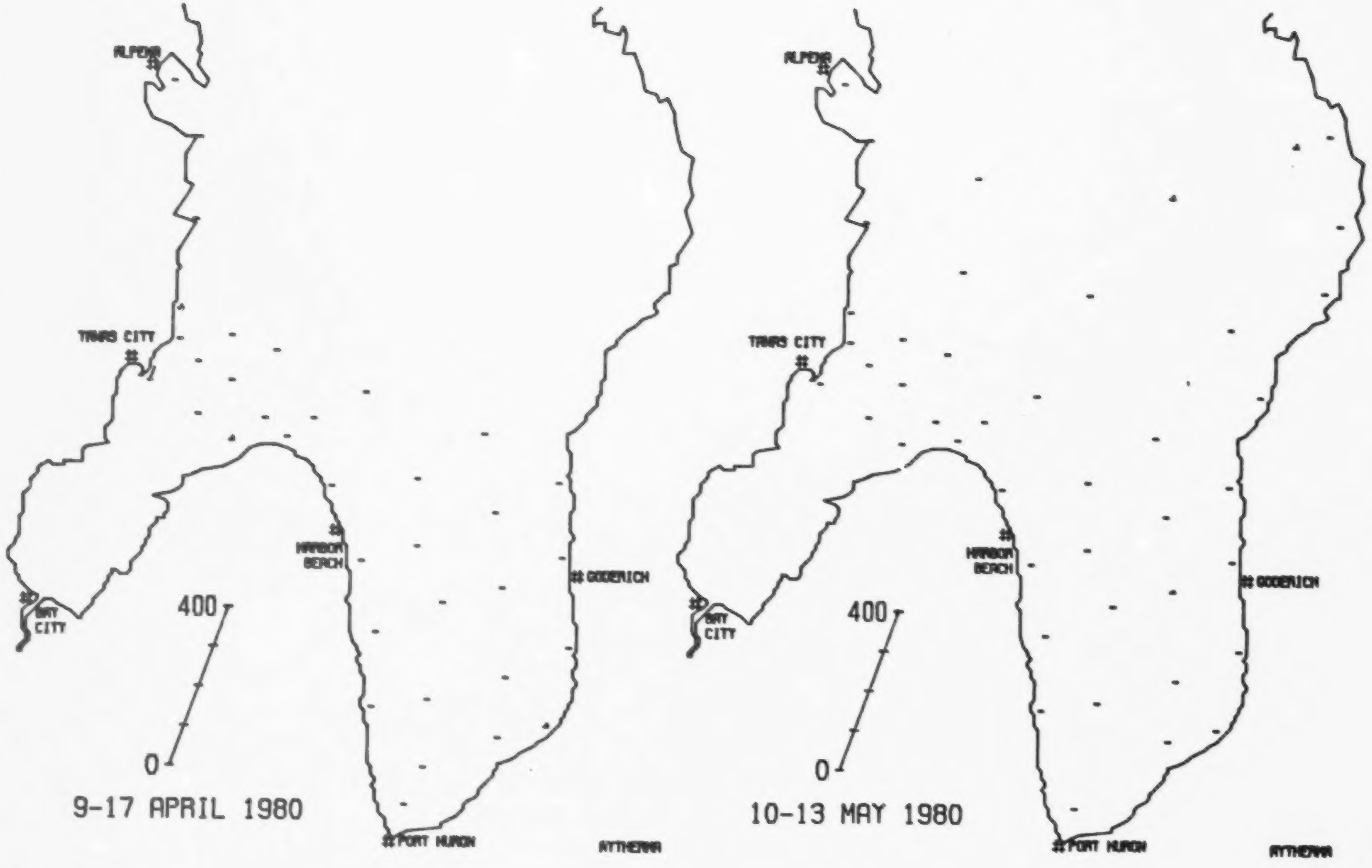
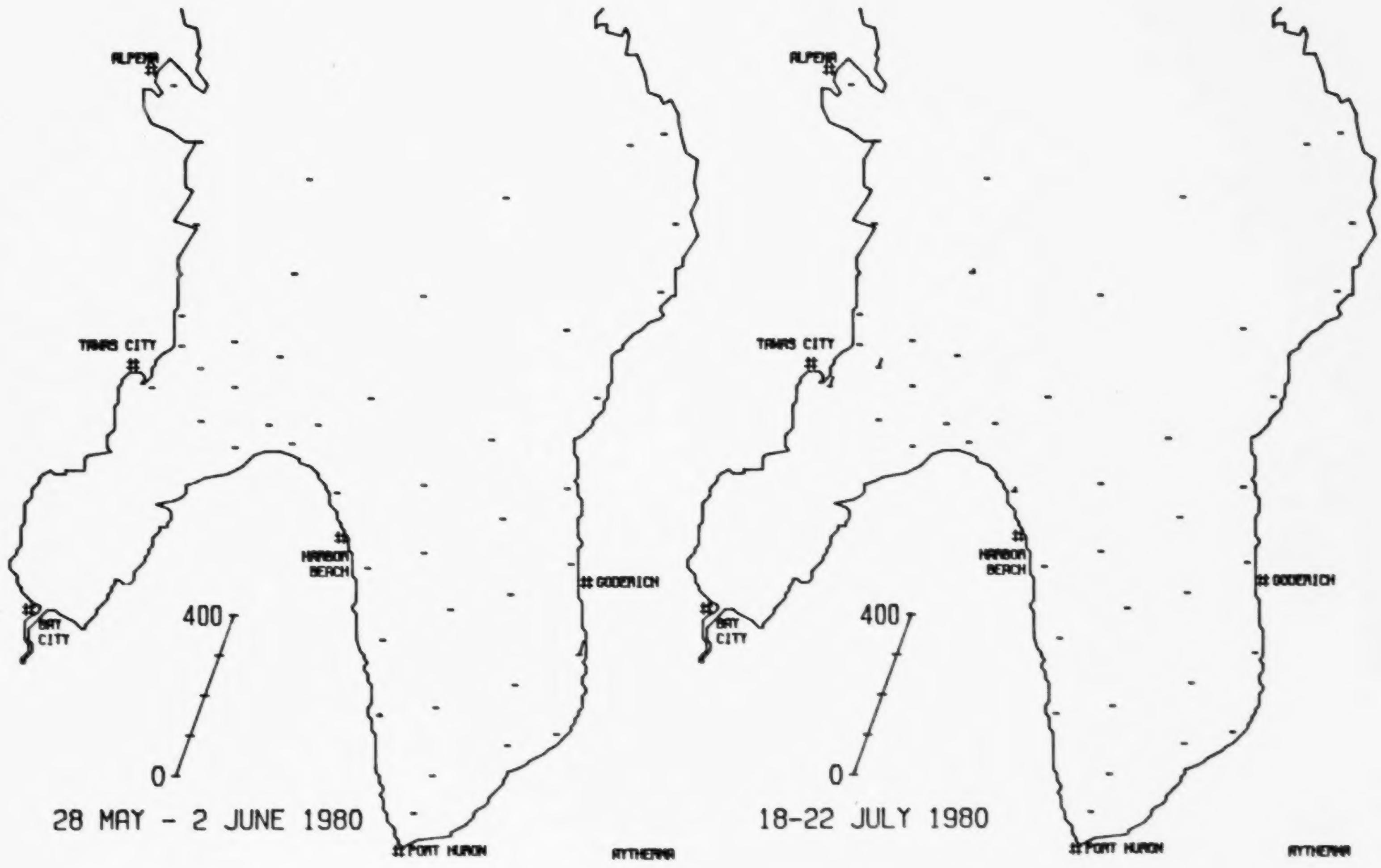

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
10-13 MAY 1980

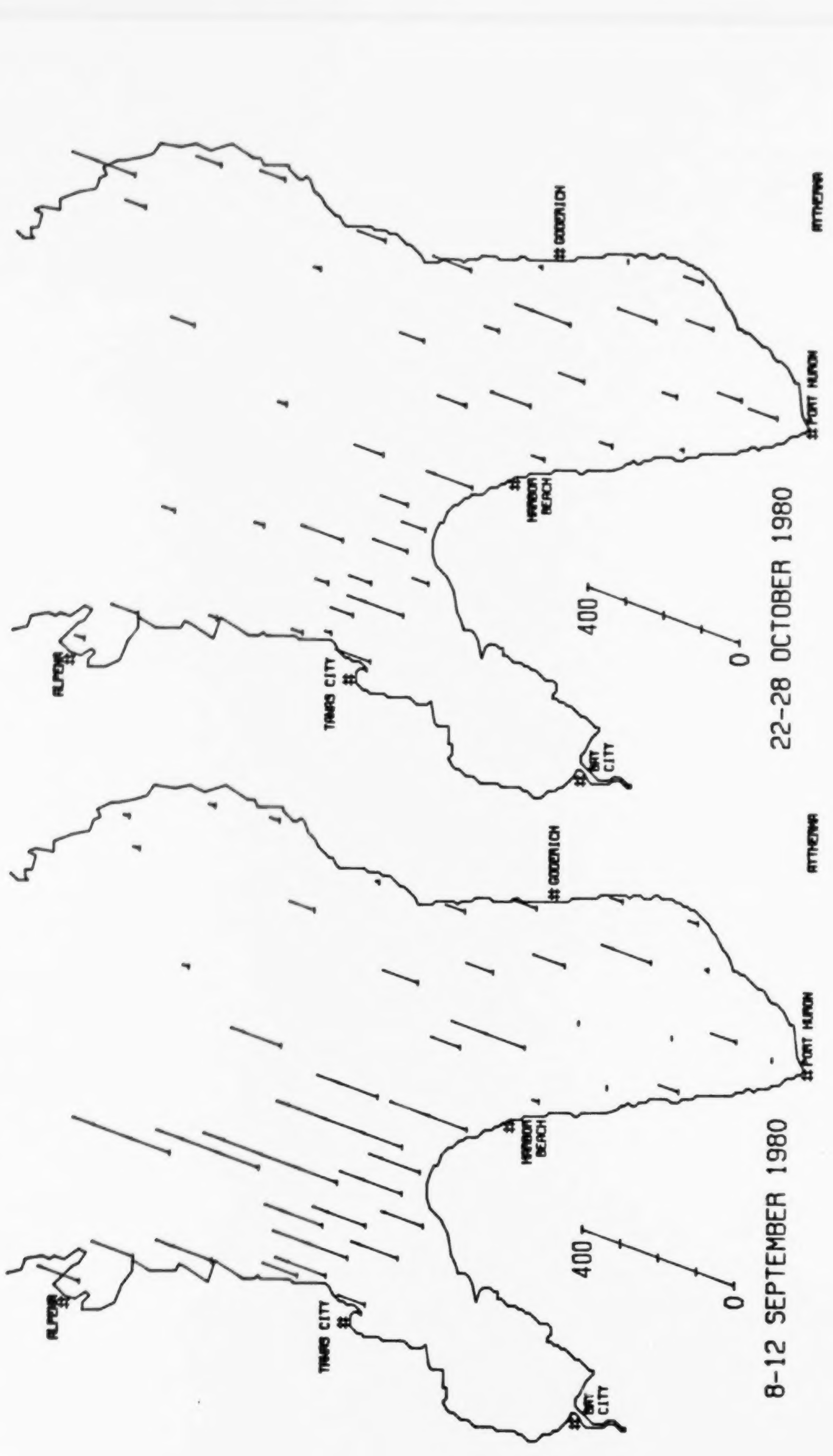
Figure 44. Distribution of _Anacystis thermalis_.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
AYTHERMA
400
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
AYTHERMA
400
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 44. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
0
400
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
0
400

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 44. (continued)

usually does not form conspicuous water blooms (Drouet and Daily 1956). Colonies of G. lacustris generally contain 75-500 individuals which are most densely packed toward the matrix periphery. In this study, on average, it was the second most abundant blue-green alga. During April (fig. 45A) occurrences at low abundance were recorded near Saginaw Bay and the southern basin. Very low abundance was observed from May through July (figs. 45B - 45D). Increased abundance was recorded in September (fig. 45E) reaching highest abundance in Thunder Bay and extending southward. Most occurrences were in the central basin and the Saginaw Bay interface zone. Distinctly less occurrences were observed in the southern basin and the eastern portion of the central basin. On average, greatest abundance and occurrence was observed in October (fig. 45F). Greatest abundance was seen in the waters adjacent to Saginaw Bay and in the mid-southern basin. Fewer occurrences and comparatively less abundances were again observed in the eastern sector of the study area.

Oscillatoria bornetii

This taxon is a filamentous blue-green alga usually found in low abundance in the plankton of the upper Great Lakes. Its autecology and distribution are very poorly known. It has however, been reported to have a wide range of tolerance from alpine lakes (Huber-Pestalozzi 1938) to meso-eutrophic waters (Van Landingham 1982). In April (fig. 46A) it was well distributed over the study area, with greatest

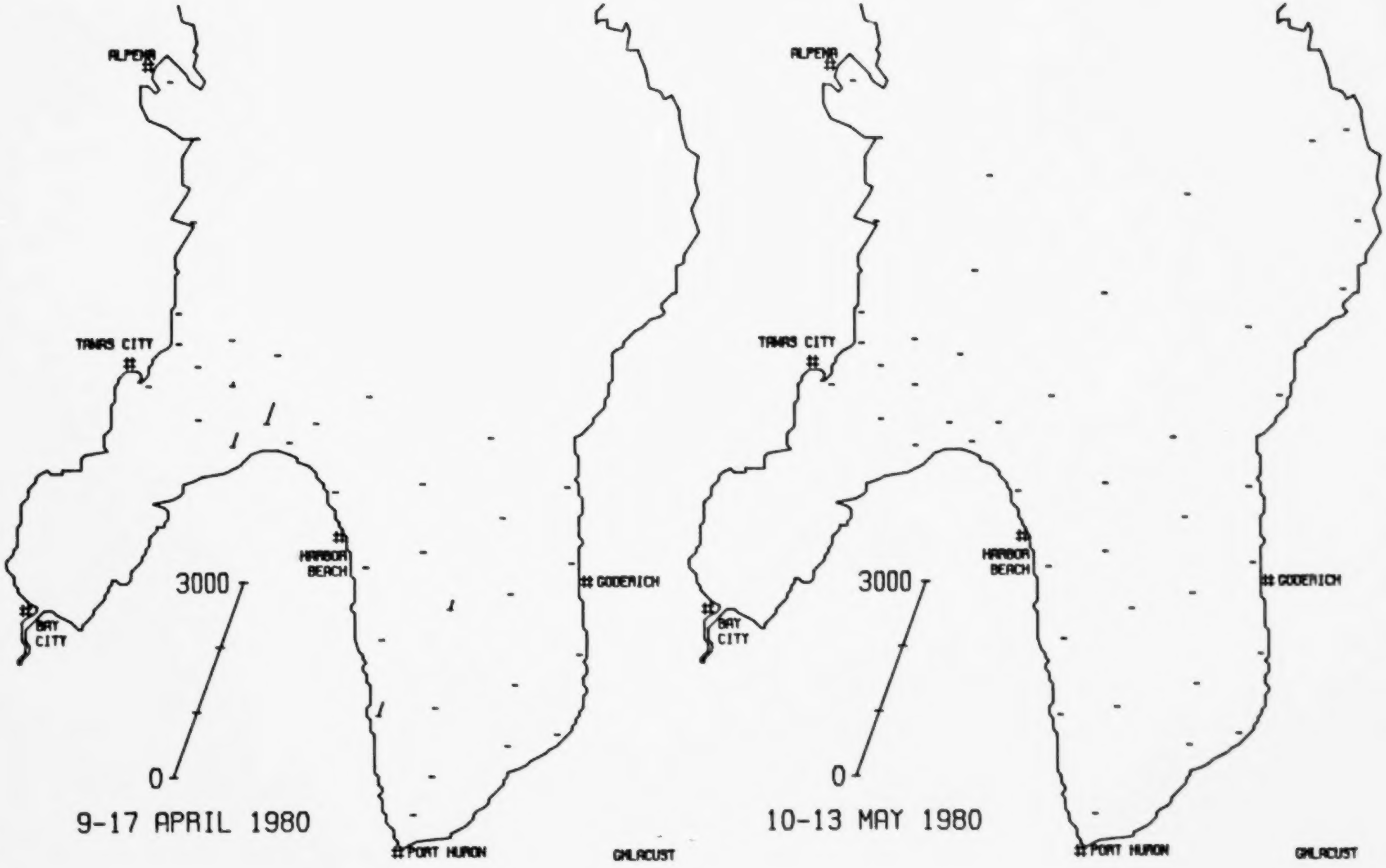

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GMLACUST
3000
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GMLACUST
3000
0
10-13 MAY 1980

Figure 45. Distribution of Gomphosphaeria lacustris.

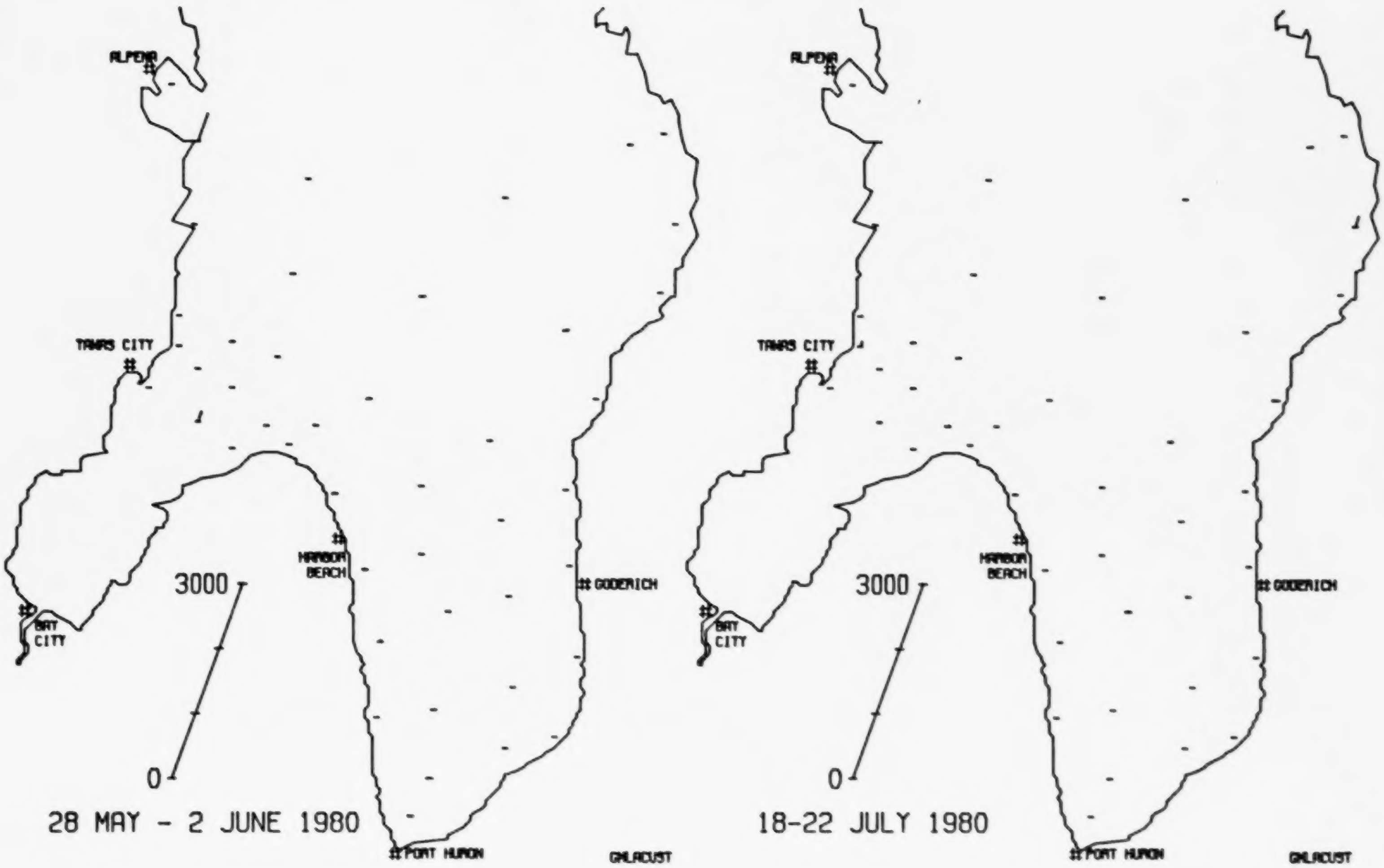

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GMLACUST
3000
0
28 MAY - 2 JUNE 1980
18-22 JULY 1980

Figure 45. (continued)

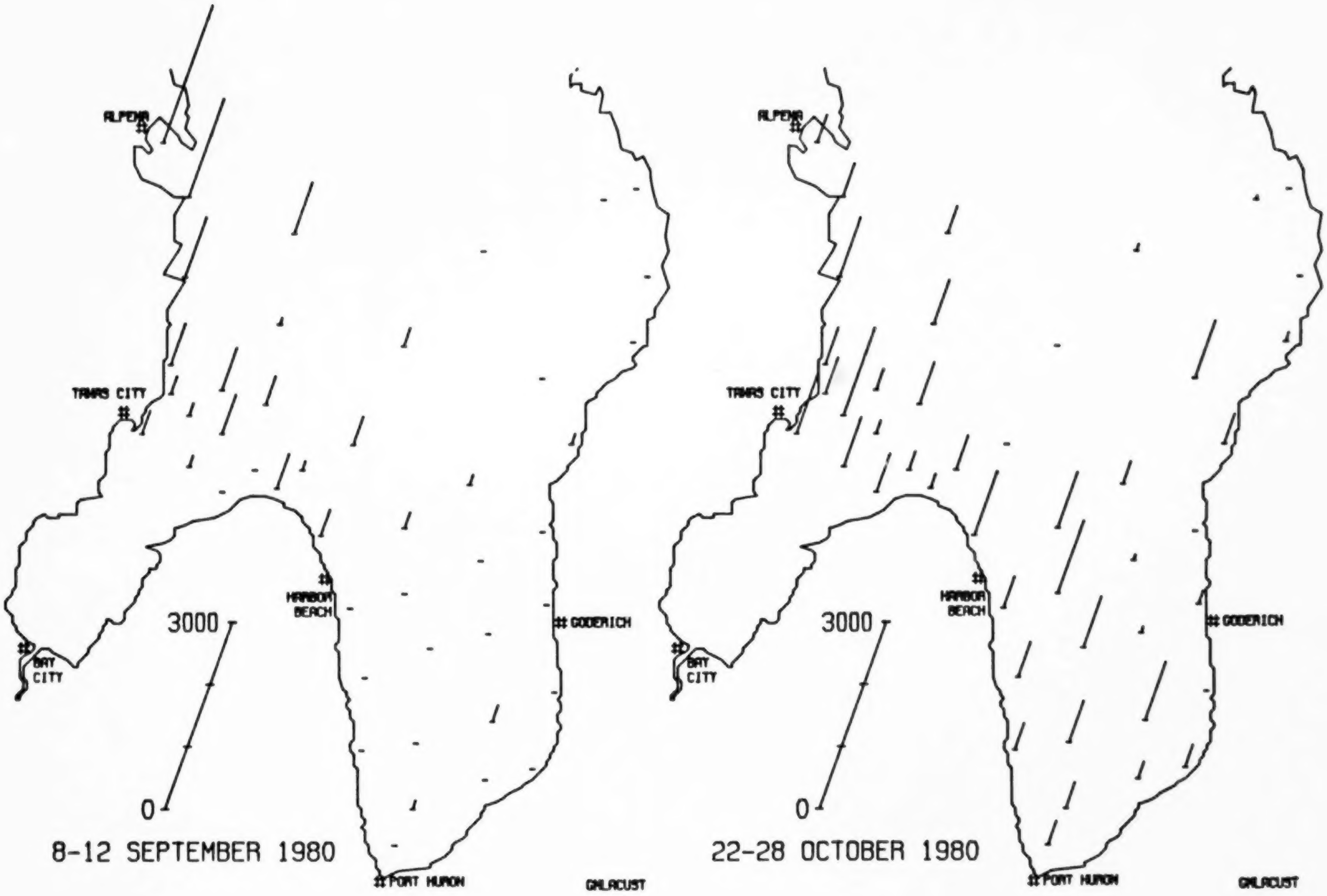
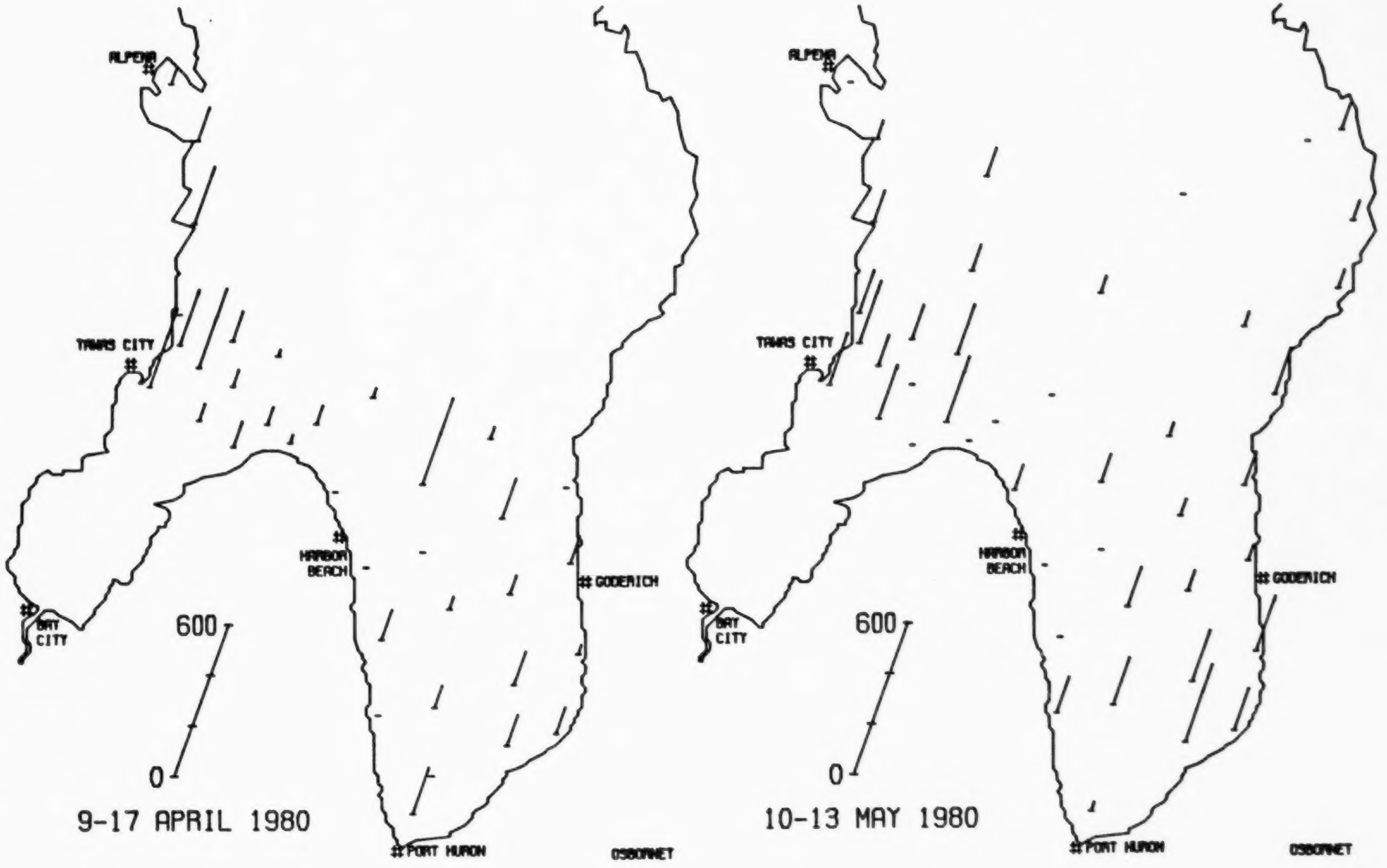

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GMLACUST
3000
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GMLACUST
3000
0
22-28 OCTOBER 1980

Figure 45. (continued)

abundance and occurrence north of Sagianw Bay. One large population was observed in the upper sector of the southern basin. During May (fig. 46B) greatest abundance again occurred north of Saginaw Bay as well as south of Goderich in the southern basin. A sporatic distribution was seen in June (fig. 46C). High abundances were observed in Thunder Bay, in the western portion of the open central basin and south of Goderich. Reduced abundances with few occurrences were observed from July through October (figs. 46D - 46F).

Schizothrix calcicola

Very little is known about the distribution and ecology of this small filamentous blue-green in the Great Lakes. It has seldom been reported from the Great Lakes in appreciable quantities. It is included here due to its odd distribution patterns. In April (fig. 47A) it occurred in the Saginaw Bay interface and southern basin. Its greatest abundance was in the coastal area between Harbor Beach and Port Huron. During May (fig. 47B) its occurrence was predominantly on the eastern side of the study area both nearshore and offshore. In June (fig. 47C) it had its greatest occurrence and abundance in the central basin with a few occurrences in the upper southern basin. Highest abundances were recorded for the Canadian nearshore zone in the central basin. From July through October (figs. 47D - 47F) sporadic occurrences at low abundances were observed.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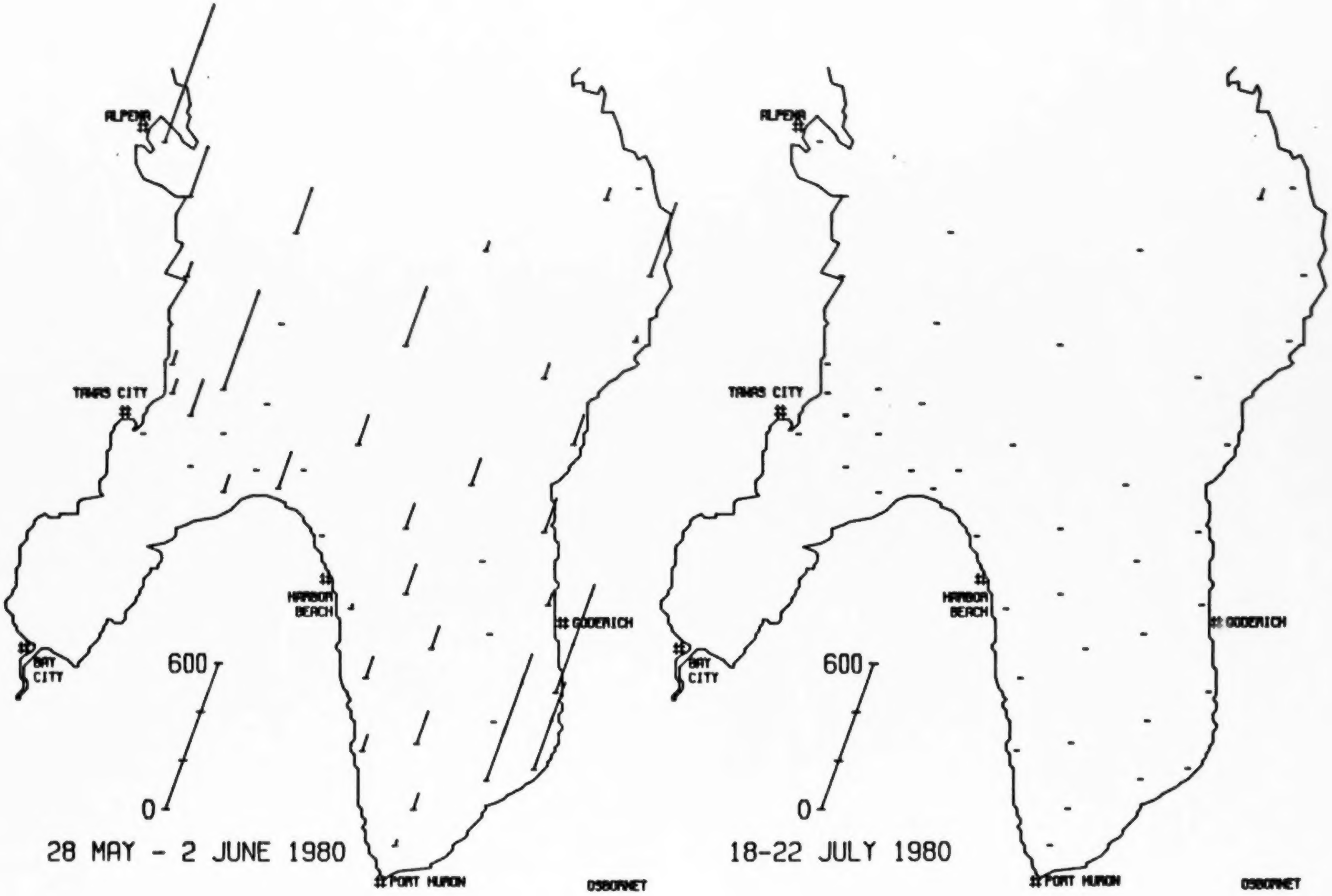
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
600
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
600
0
10-13 MAY 1980

Figure 46. Distribution of Oscillatoria bornetii.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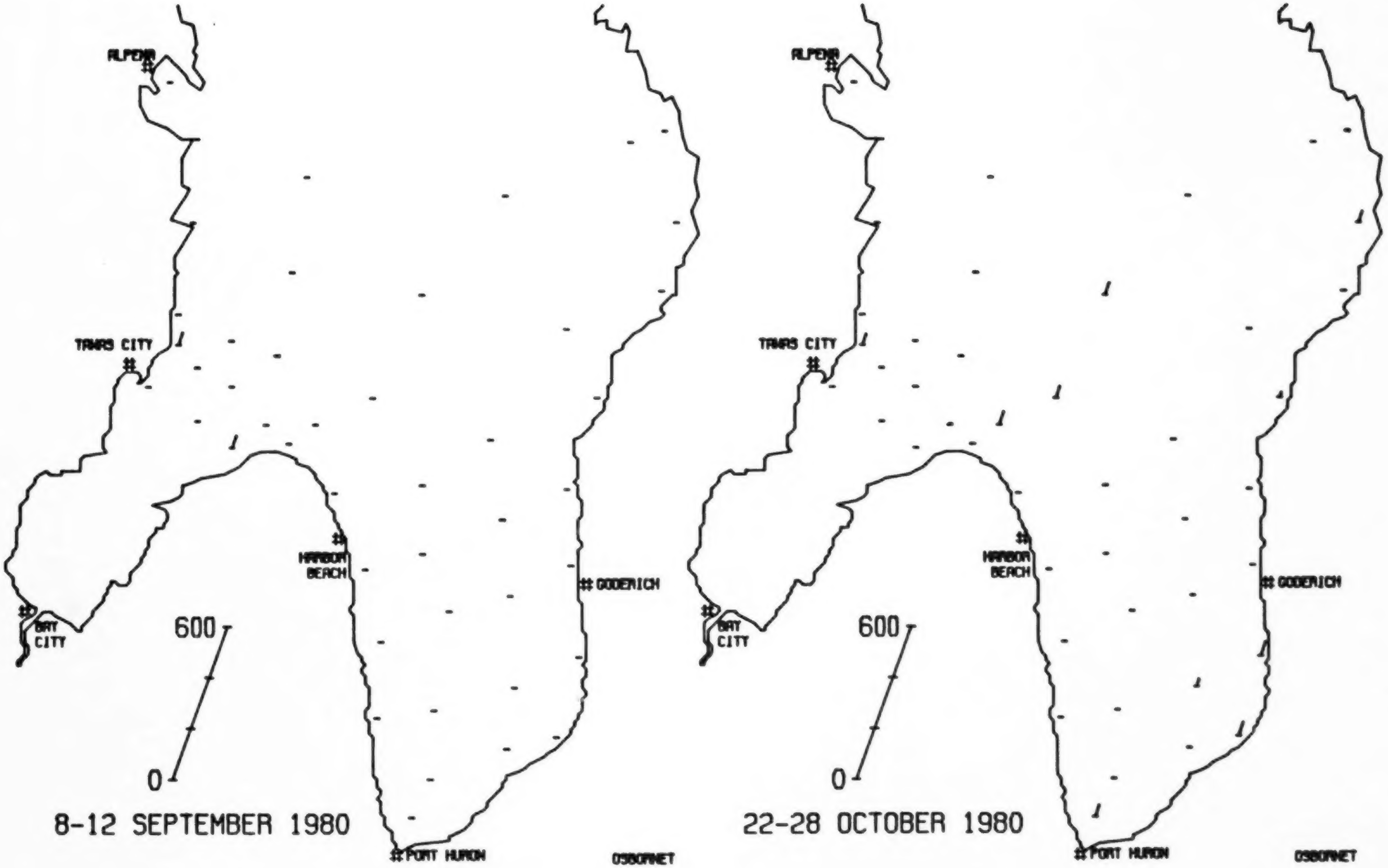
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
600
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
600
0
18-22 JULY 1980

Figure 46. (continued)


8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
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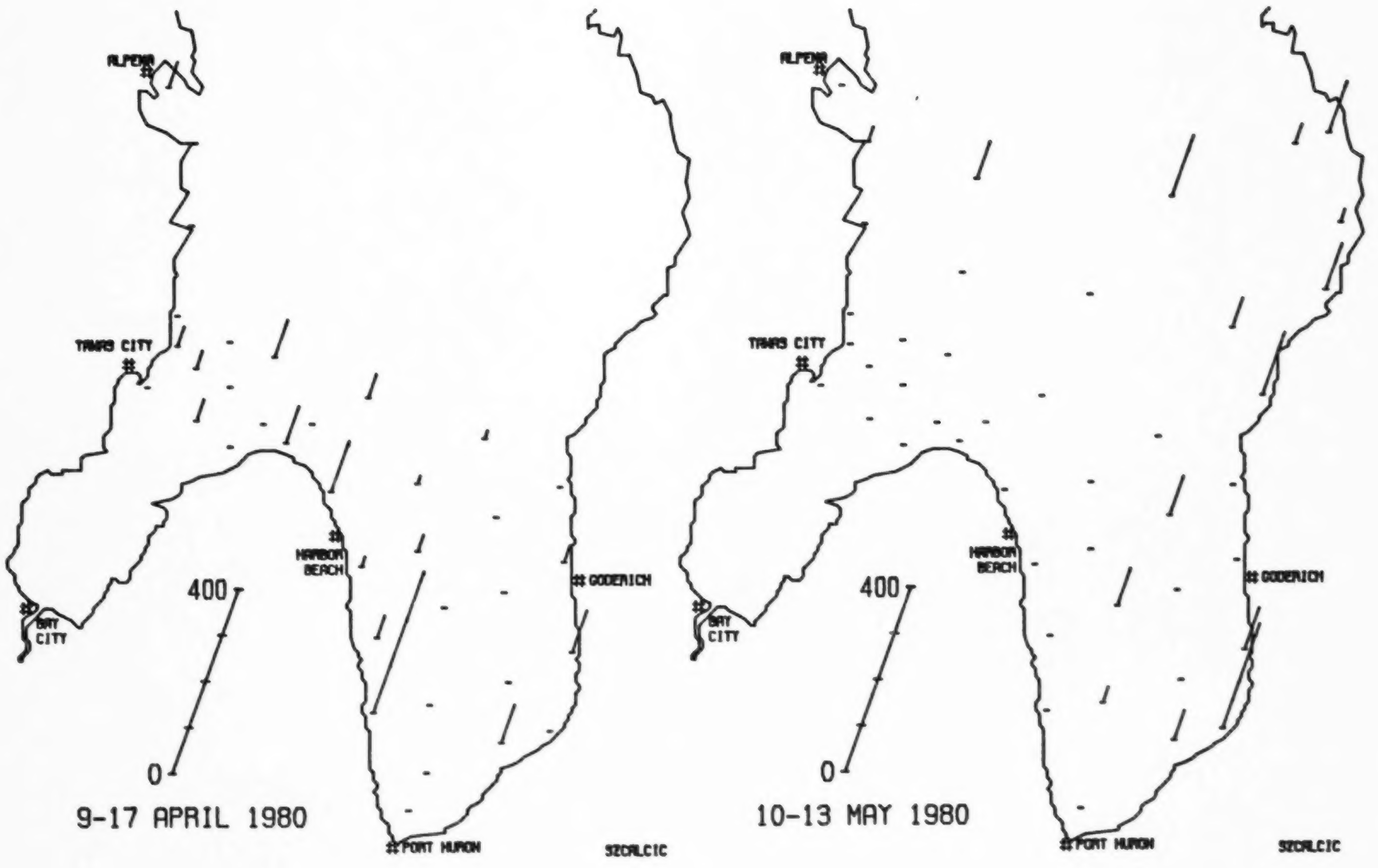
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
OSBORNET
600
0

Figure 46. (continued)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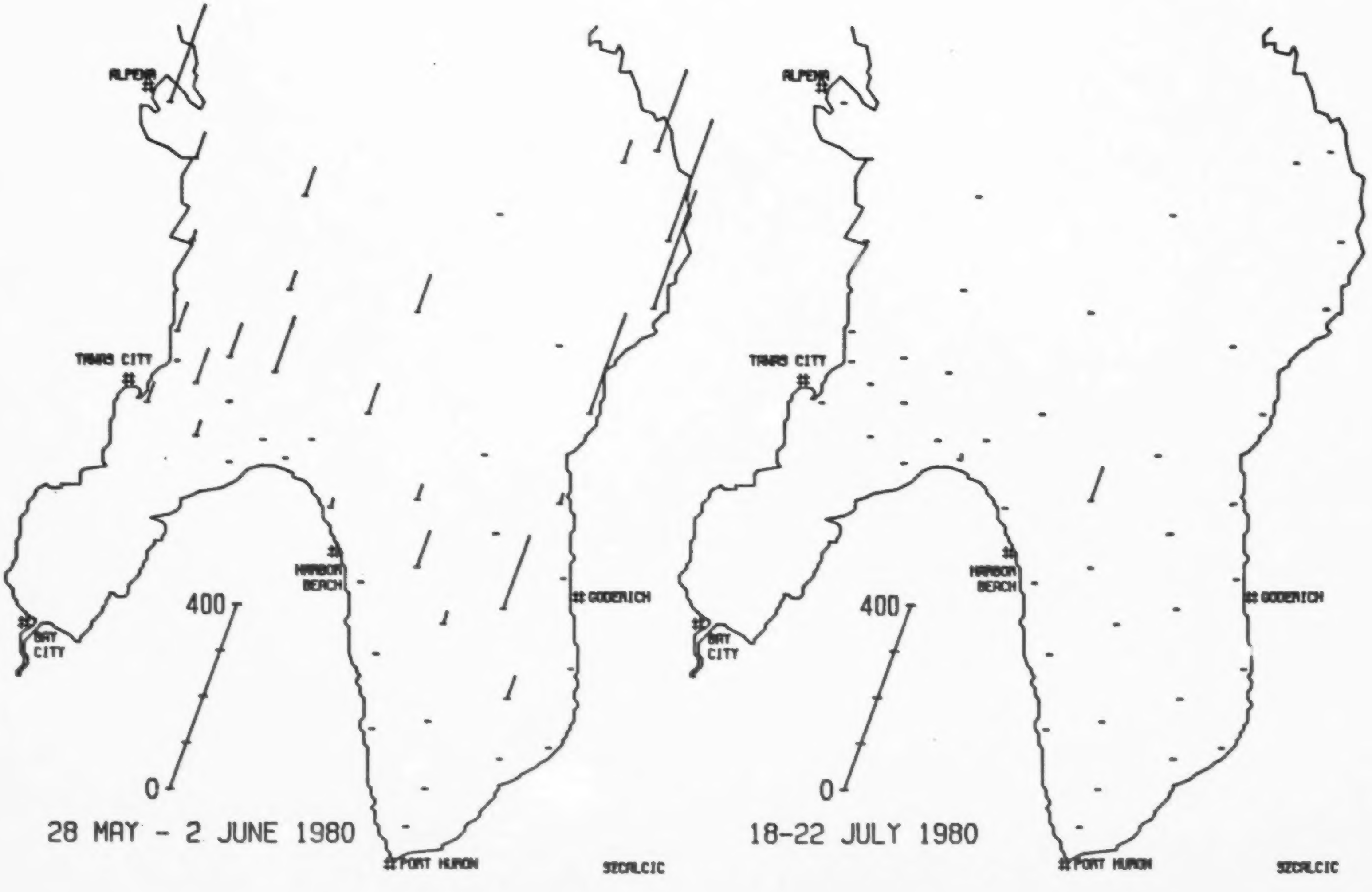
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
9-17 APRIL 1980
SZCALCIC
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
10-13 MAY 1980
SZCALCIC

Figure 47. Distribution of Schizothrix calcicola.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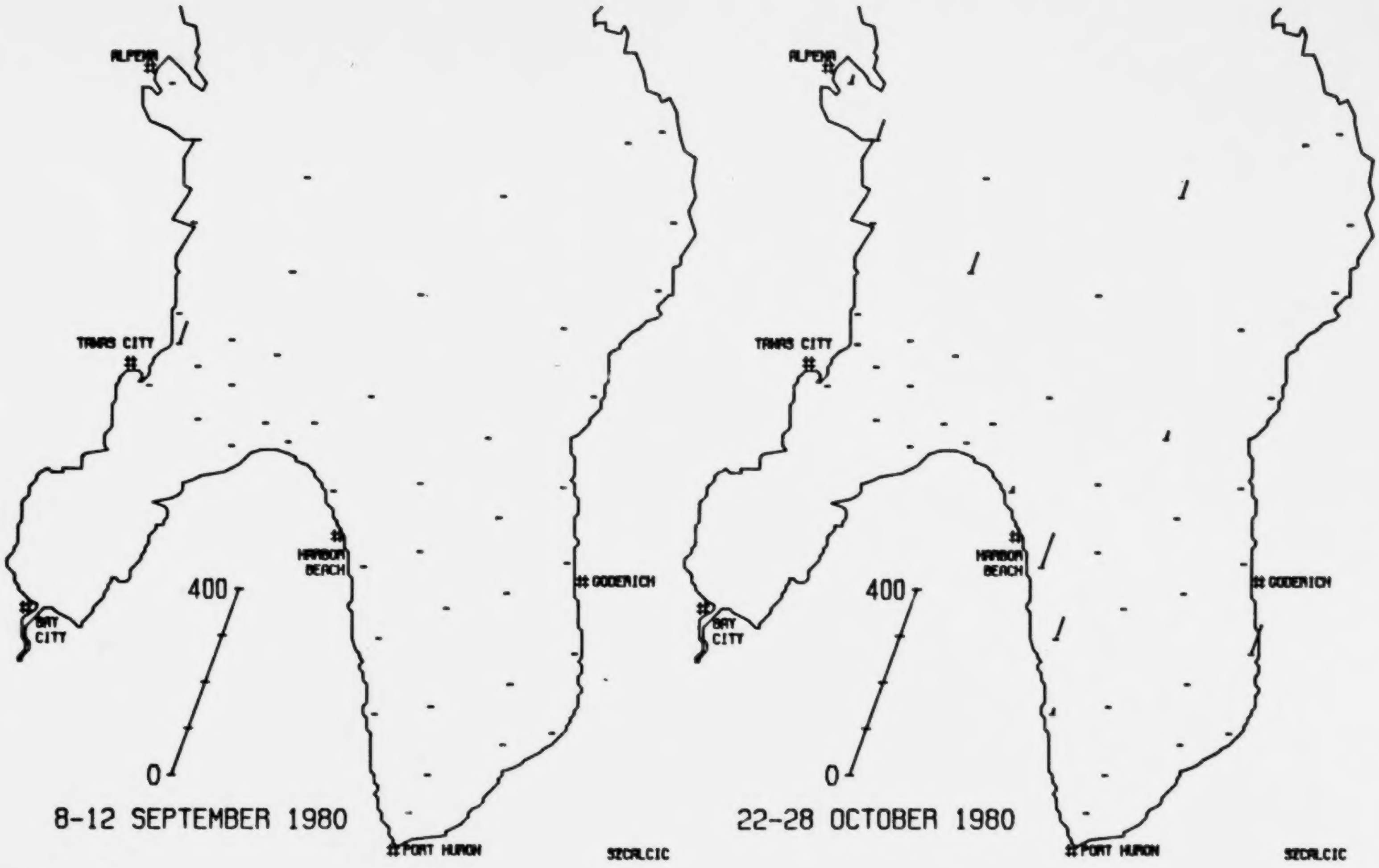
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SZCALCIC
400
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SZCALCIC
400
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 47. (continued)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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SZCALCIC
400
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
SZCALCIC
400
0

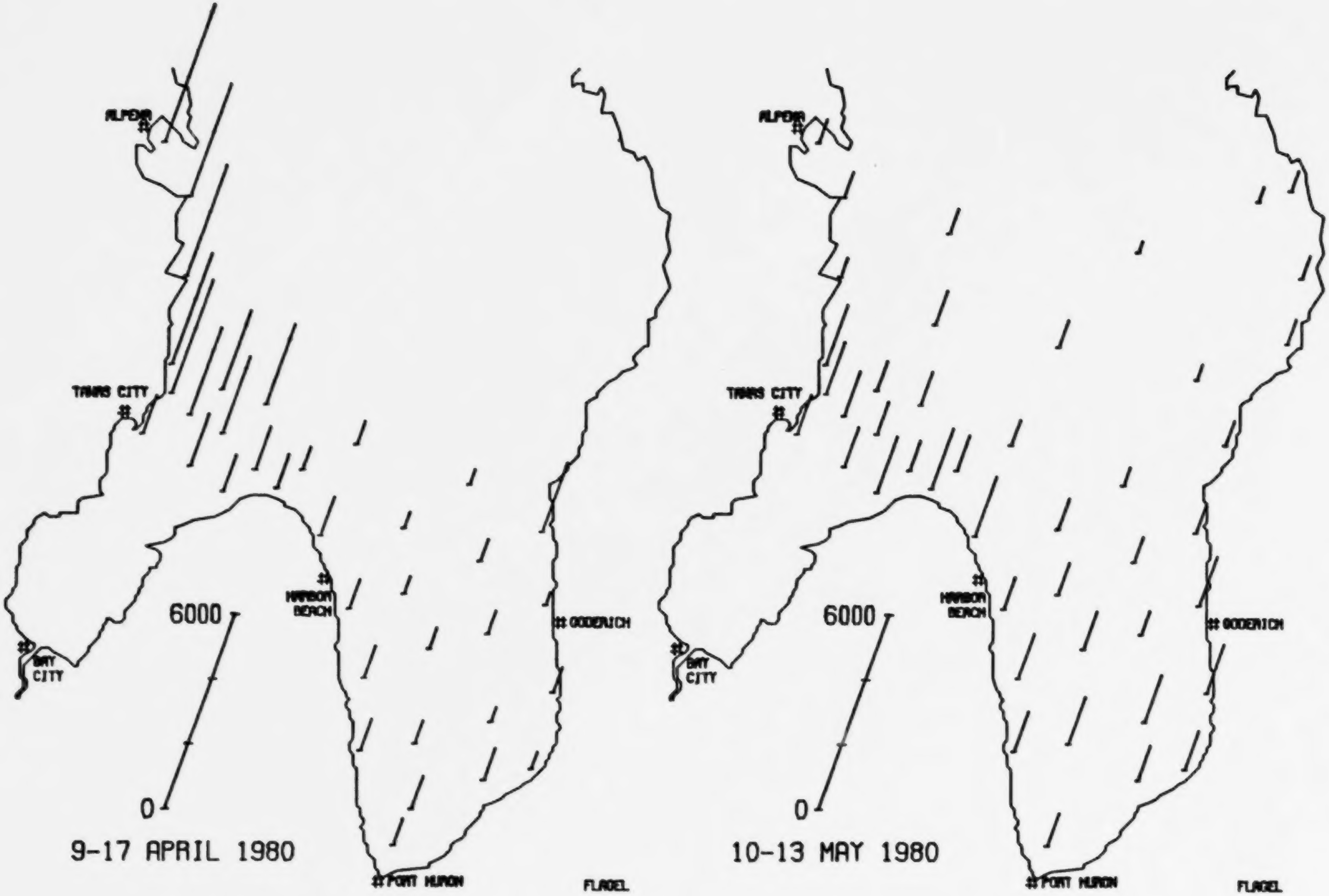
8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 47. (continued)

TOTAL FLAGELLATES

This category is a composite of all microflagellates comprised of all flagellate groups from the Chrysophyta, Cryptophyta, Pyrrhophyta, Euglenophyta and the undetermined category. Collectively, they constitute a considerable portion of southern Lake Huron phytoplankton assemblages. They were most abundant during the spring sampling periods. During April (fig. 48A) flagellates reached their highest average abundance for the season. Abundances were highest in Thunder Bay and in the nearshore zone southward to Tawas City. Abundances were also high in the northern portion of the Saginaw Bay interface. Lower uniform abundance was observed in the southern basin. During May (fig. 48B), on average, slightly reduced abundances were observed. Highest abundances were recorded in the Saginaw Bay interface. Compared to April, slightly increased cell numbers were observed in the southern basin. Decreased abundance was observed in the nearshore zone between Alpena and Tawas City. Remarkably uniform, moderate abundances were recorded in June (fig. 48C). In July (fig. 48D) abundances decreased, especially in outer Saginaw Bay and the southern basin. Highest cell numbers were reported for the mid-central basin during this month. During September and October (figs. 48E and 48F) rather uniform distribution and abundances were observed.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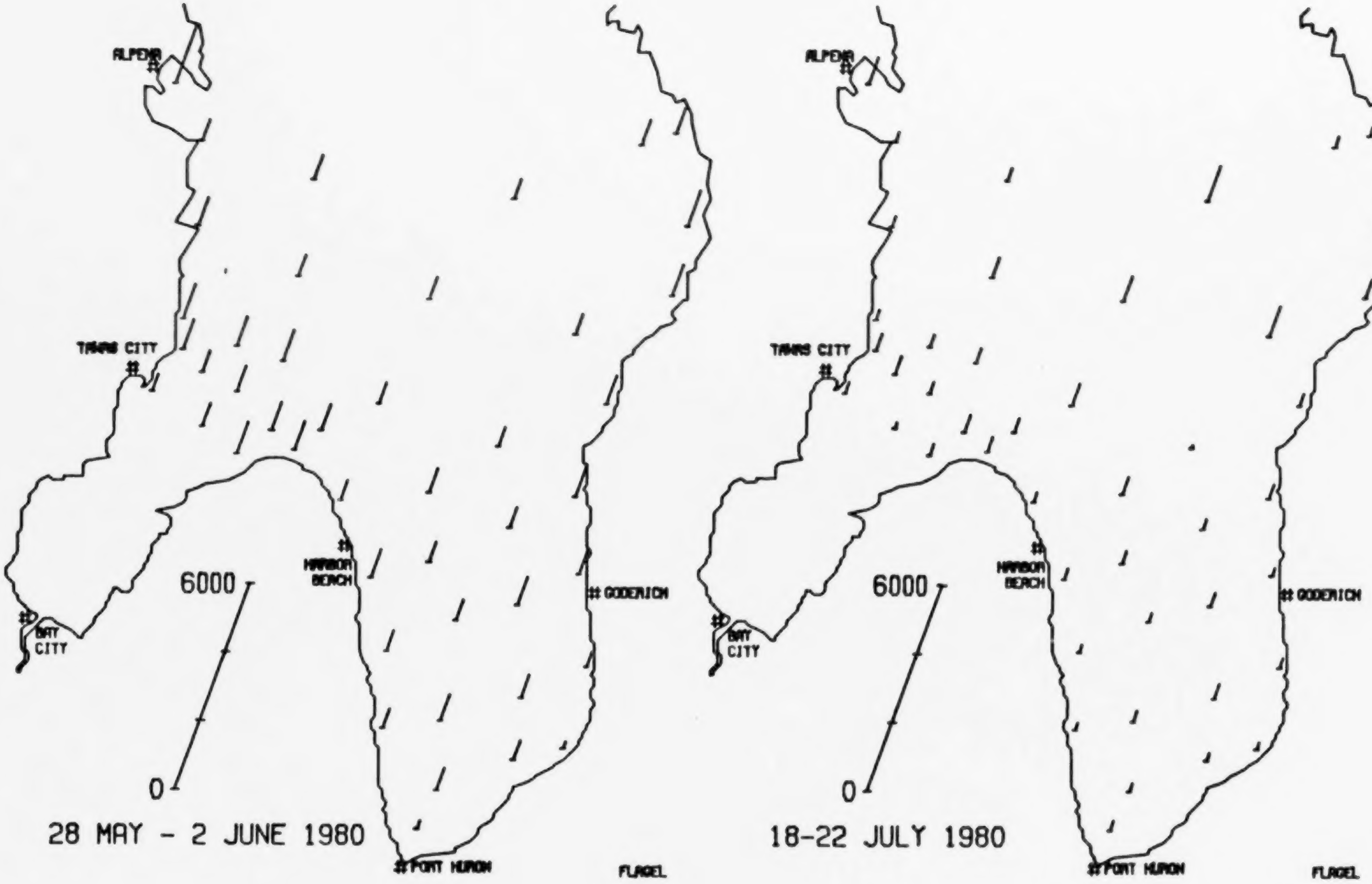
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
6000
0
9-17 APRIL 1980
FLAGEL
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
6000
0
10-13 MAY 1980
FLAGEL

Figure 48. Seasonal distribution and abundance trends of Total Flagellates.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TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLAGEL
6000
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLAGEL
6000
0
18-22 JULY 1980

Figure 48. (continued)

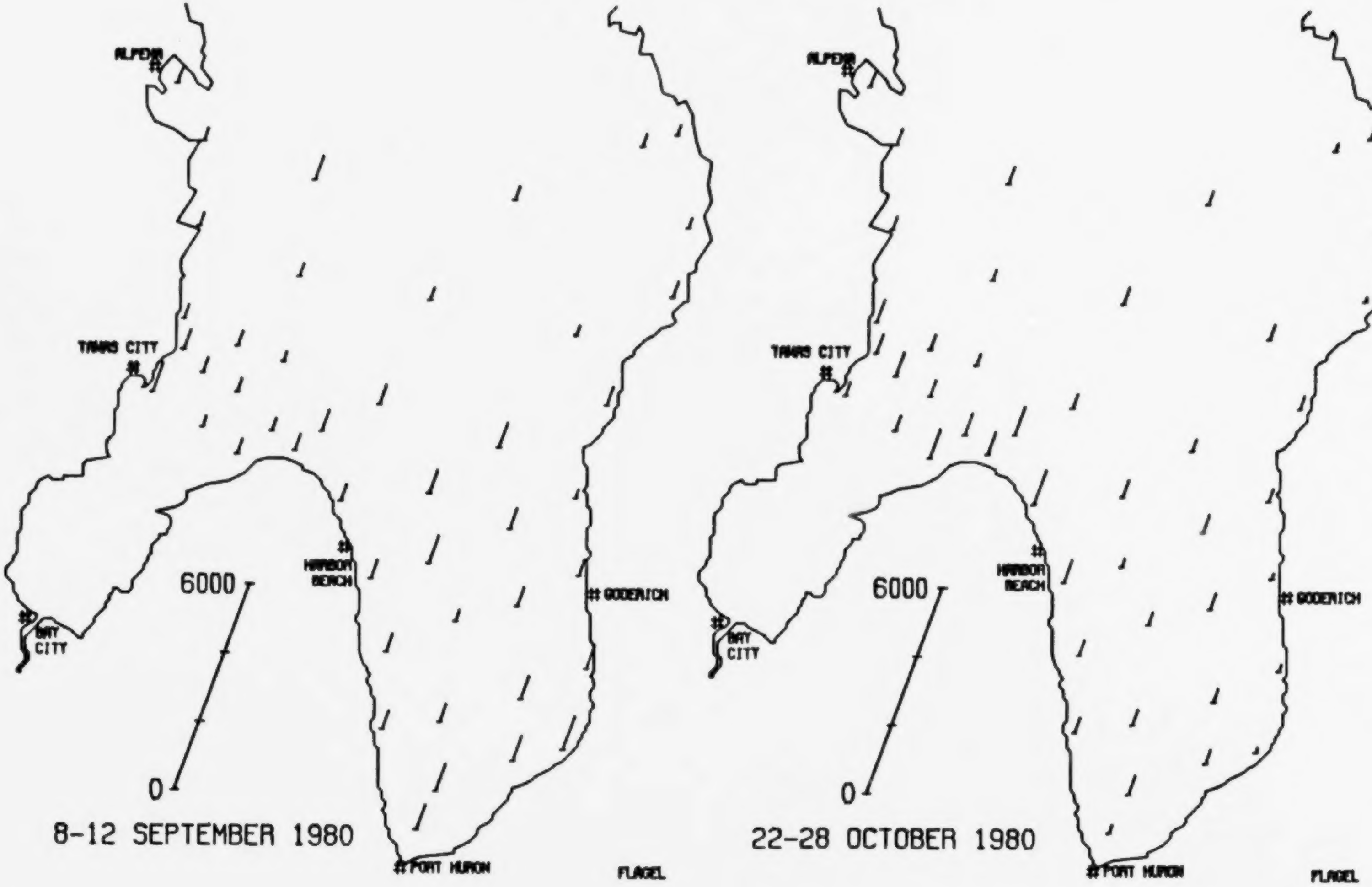

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLAGEL
6000
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLAGEL
6000
0
22-28 OCTOBER 1980

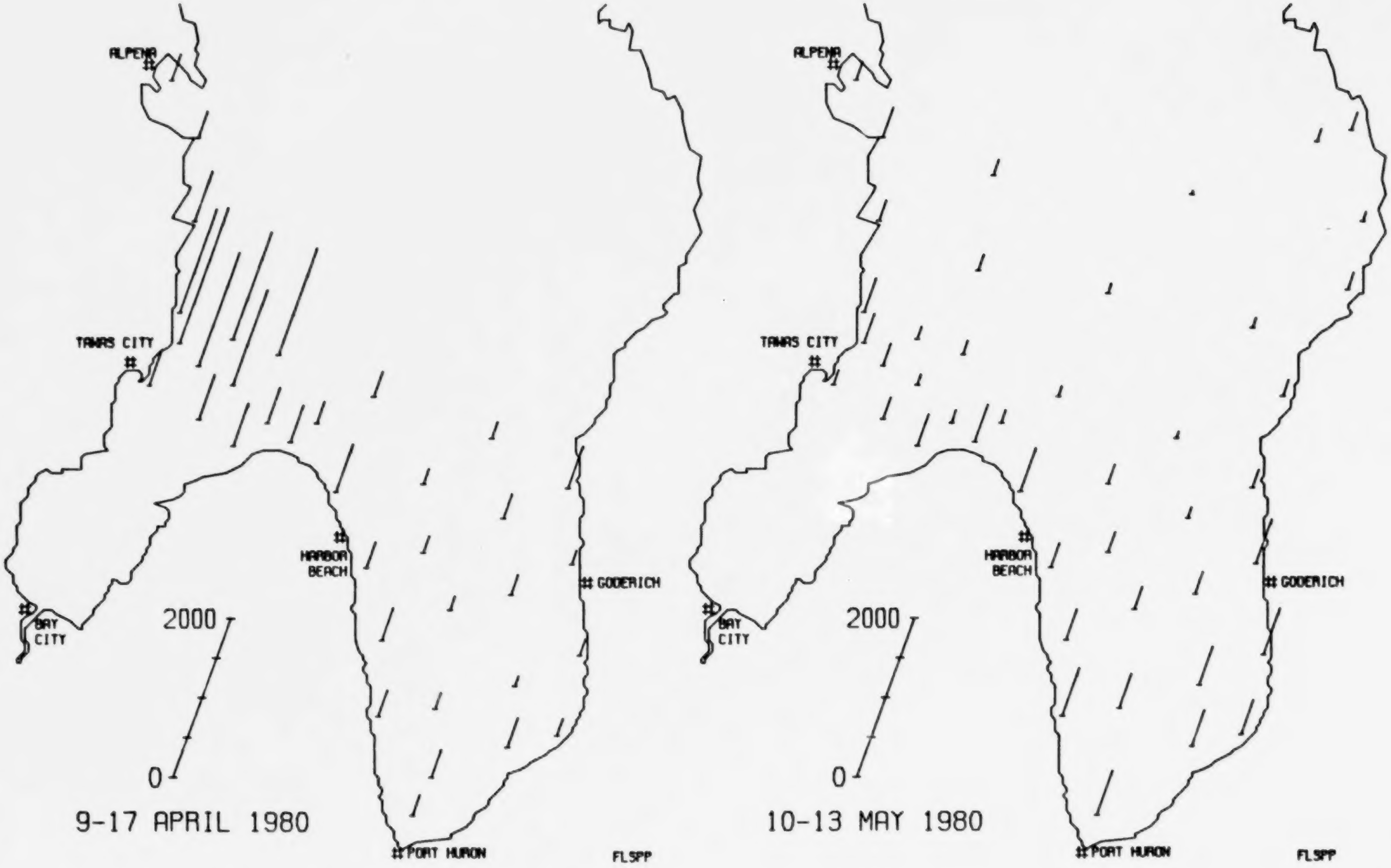
Figure 48. (continued)

Undetermined microflagellates

The abundances and distribution patterns reported for total flagellates were also observed for the undetermined flagellate category (figs. 49A - 49F). Considering the large proportion of undetermined microflagellates in the total flagellate values, the similarity is reasonably expected. This category is comprised of small forms possibly aligned with little known groups in the Great Lakes such as the haptophytes, chloromonads and chrysophytes as previously mentioned.

Flagellate sp. #15

This flagellate form could not be aligned with a known taxonomic entity and has not been previously observed in the Great Lakes. It is very small, approximately 4um in diameter, exhibiting an oval cell shape. There is a possibility that it also occurs in a colonial habit. It reached its greatest abundance for the season in April (fig. 50A) in the nearshore area between Alpena and Tawas City. These abundances accounted for the large values observed in the total flagellate category at this location. Although it is not assigned to a specific taxon it could be separated by its morphological characters. It was also moderately abundant in outer Saginaw Bay and slightly higher in the interface zone. During May (fig. 50B) it reached its widest distribution with greatest abundance in outer Saginaw Bay, the interface area and the lower southern basin. For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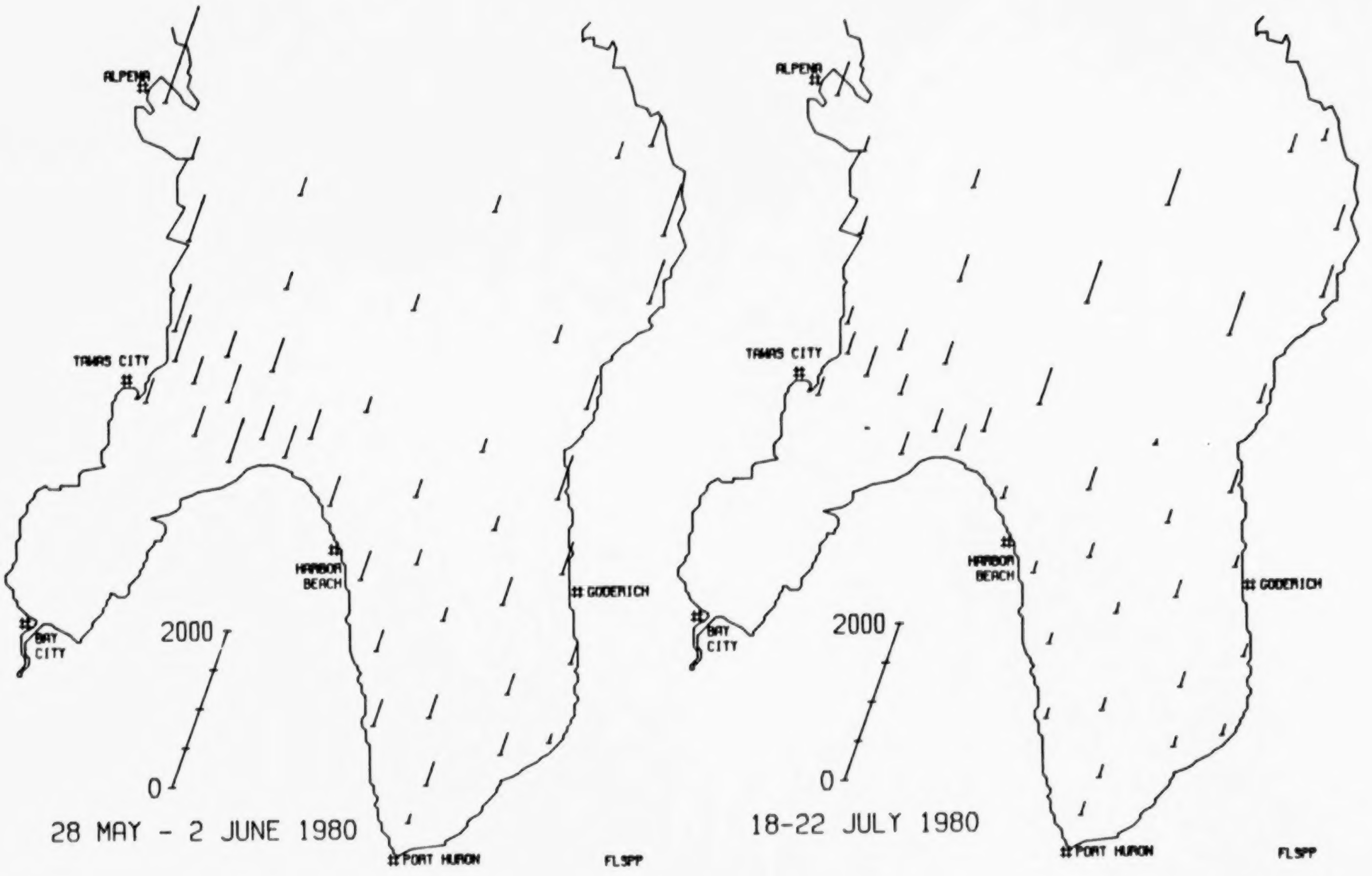
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
2000
0
9-17 APRIL 1980
FLSPP
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
2000
0
10-13 MAY 1980
FLSPP

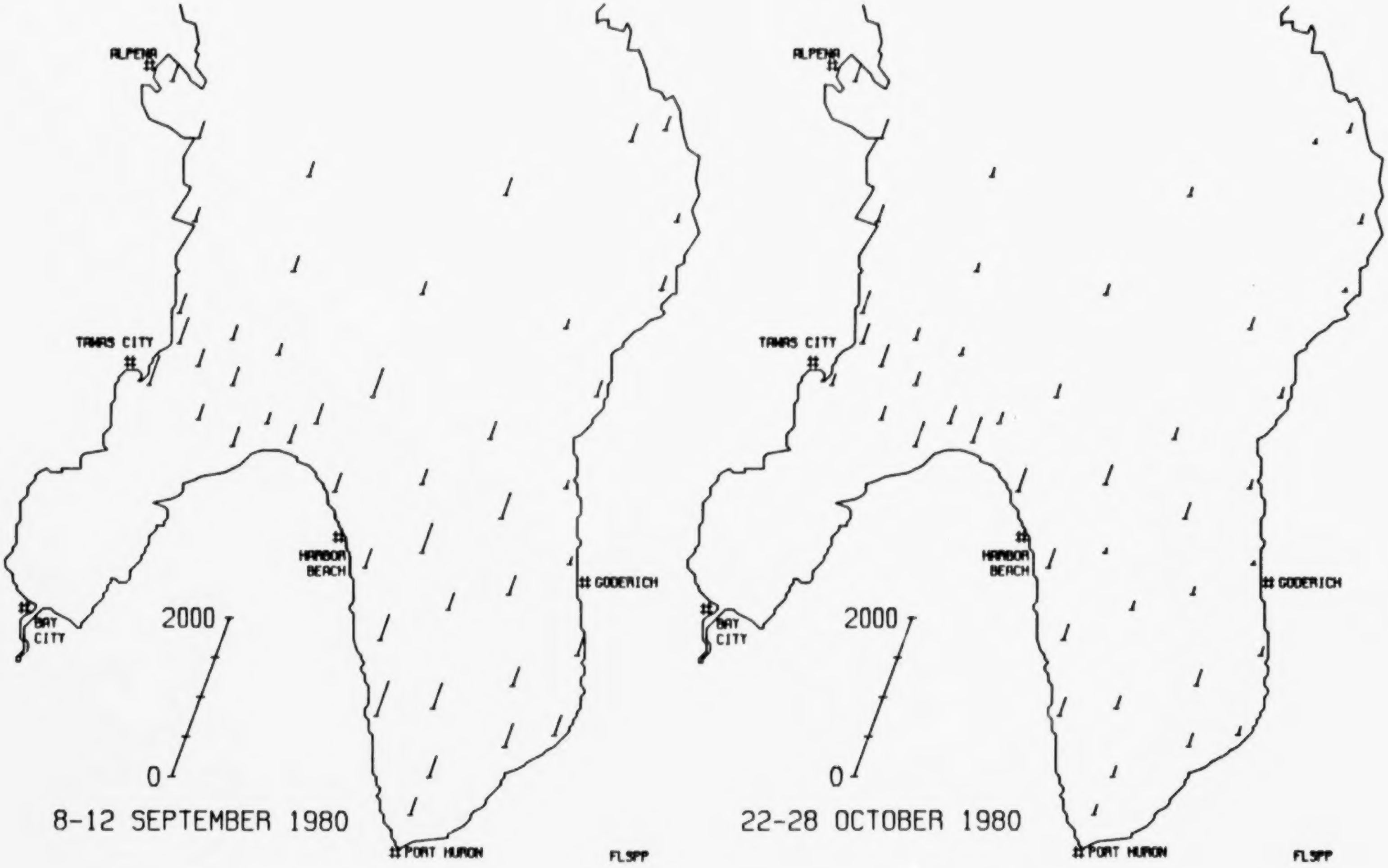
Figure 49. Distribution of undetermined microflagellates.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLSPP
2000
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 49. (continued)


8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

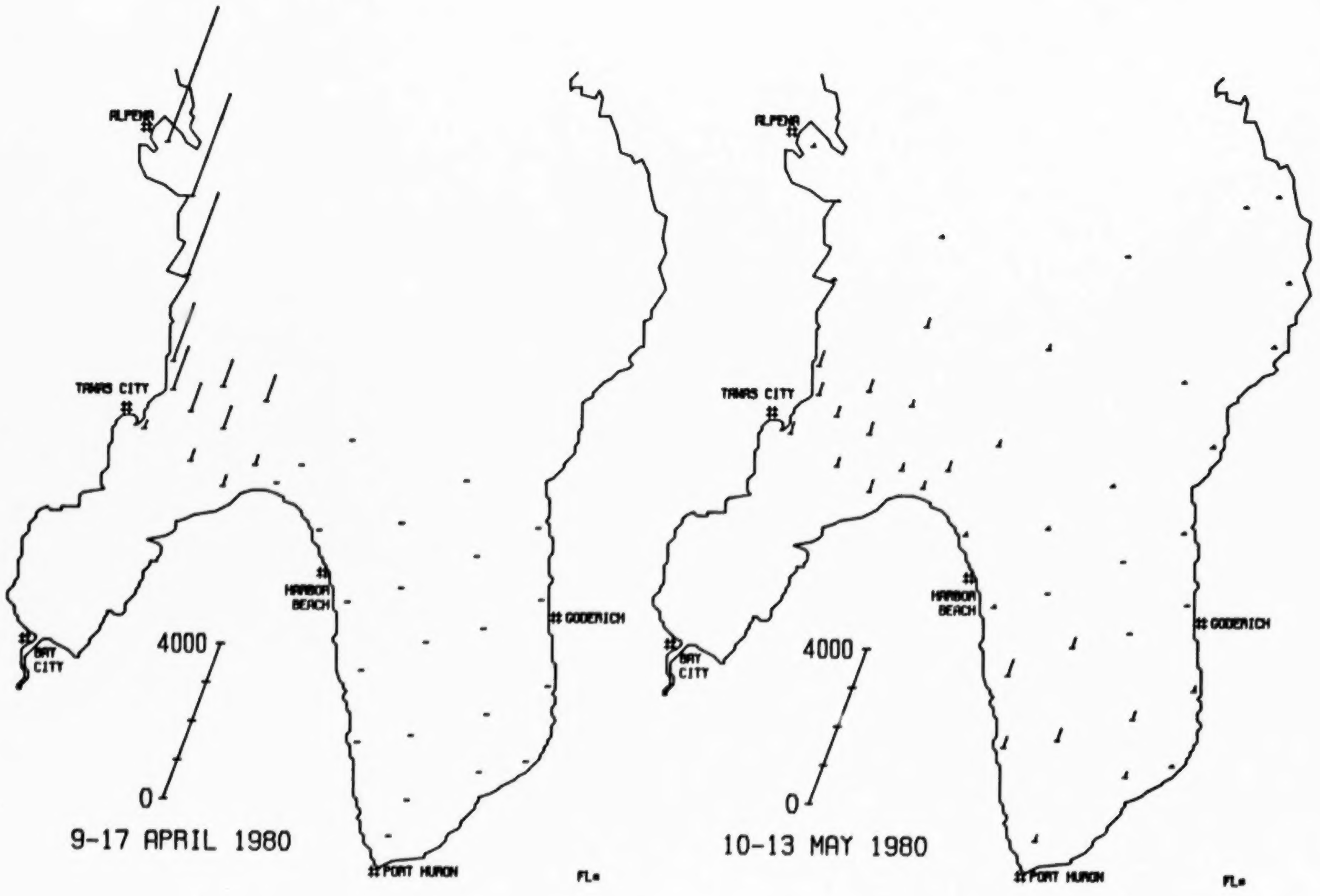
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
FLSPP
2000
0

Figure 49. (continued)

the remainder of the year (figs. 50C - 50F) extremely low abundances were recorded.

CHRYSOPHYTA - CHRYSOPHYTES

The chrysophytes have long been recognized as an important component of the algal flora of the upper Great Lakes. The Laurentian Great Lakes have been referred to as 'diatom and chrysophyte lakes' in reference to their dominance in net plankton tows taken in the early stages of phytoplankton research. Various chrysophytes have been associated with oligotrophy but occur in the entire trophic spectrum (Hutchinson 1967). The majority of chrysophytes observed in southern Lake Huron are flagellated colonial forms. During April and May they reached their greatest seasonal abundance and occurrence in southern Lake Huron. In April (fig. 51A) chrysophytes were present in moderately abundant concentrations over the survey area. Greatest abundance was seen at one nearshore station north of Goderich. High values were also reported near Alpena and in Saginaw Bay. During May (fig. 51B) cell numbers increased to their greatest abundance for the season. Highest values were observed in the waters adjacent to Saginaw Bay with lower values observed in the central basin. Reduced abundance was observed in June (fig. 51C) showing a uniform distribution. Lowest abundances for the season were seen in July (fig. 51D) although they were present at most stations. Greatest standing crops were observed in the Sagianw Bay interface wates and the central basin. Increased abundance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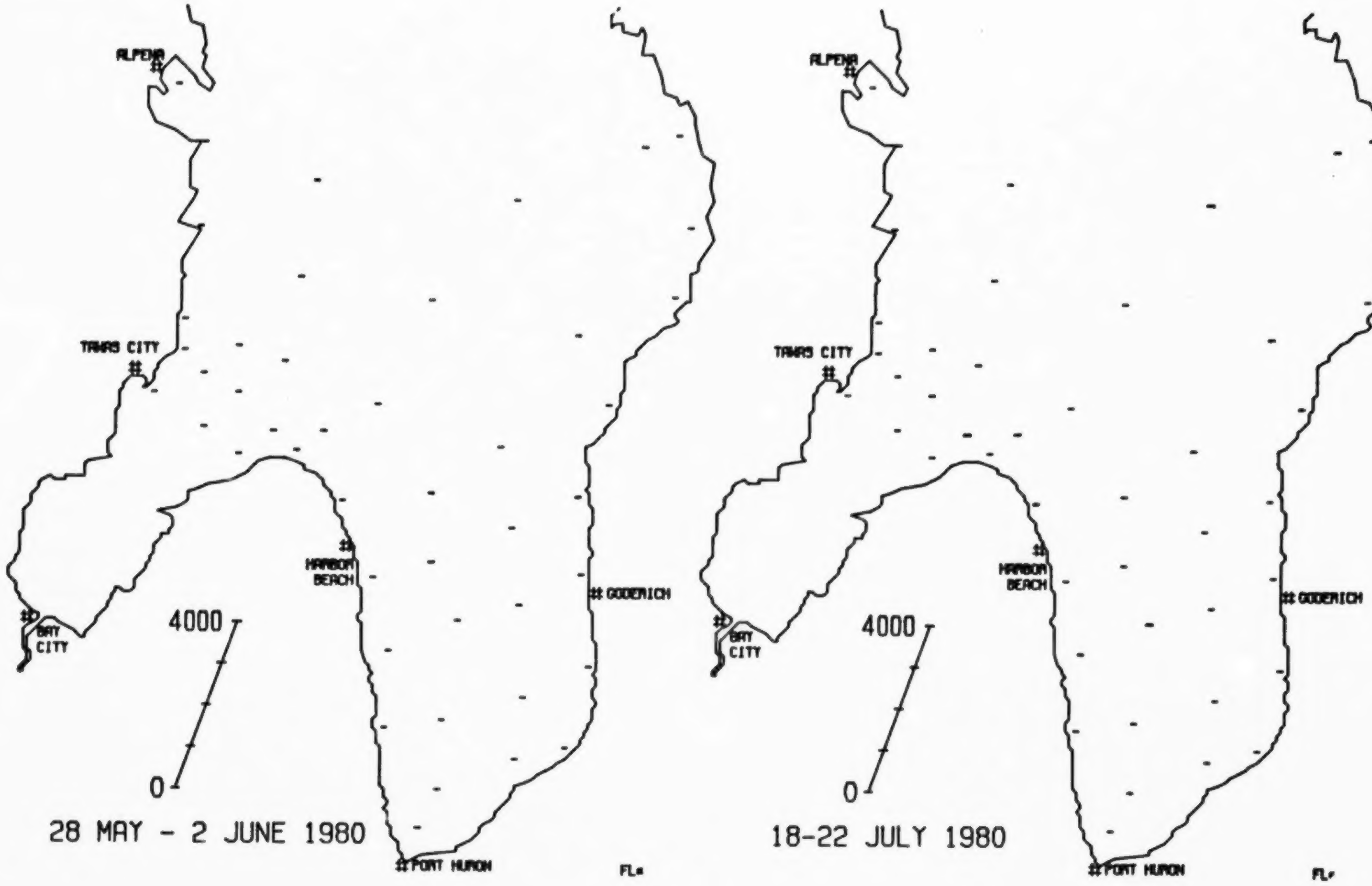
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
9-17 APRIL 1980
FL=
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
10-13 MAY 1980
FL=

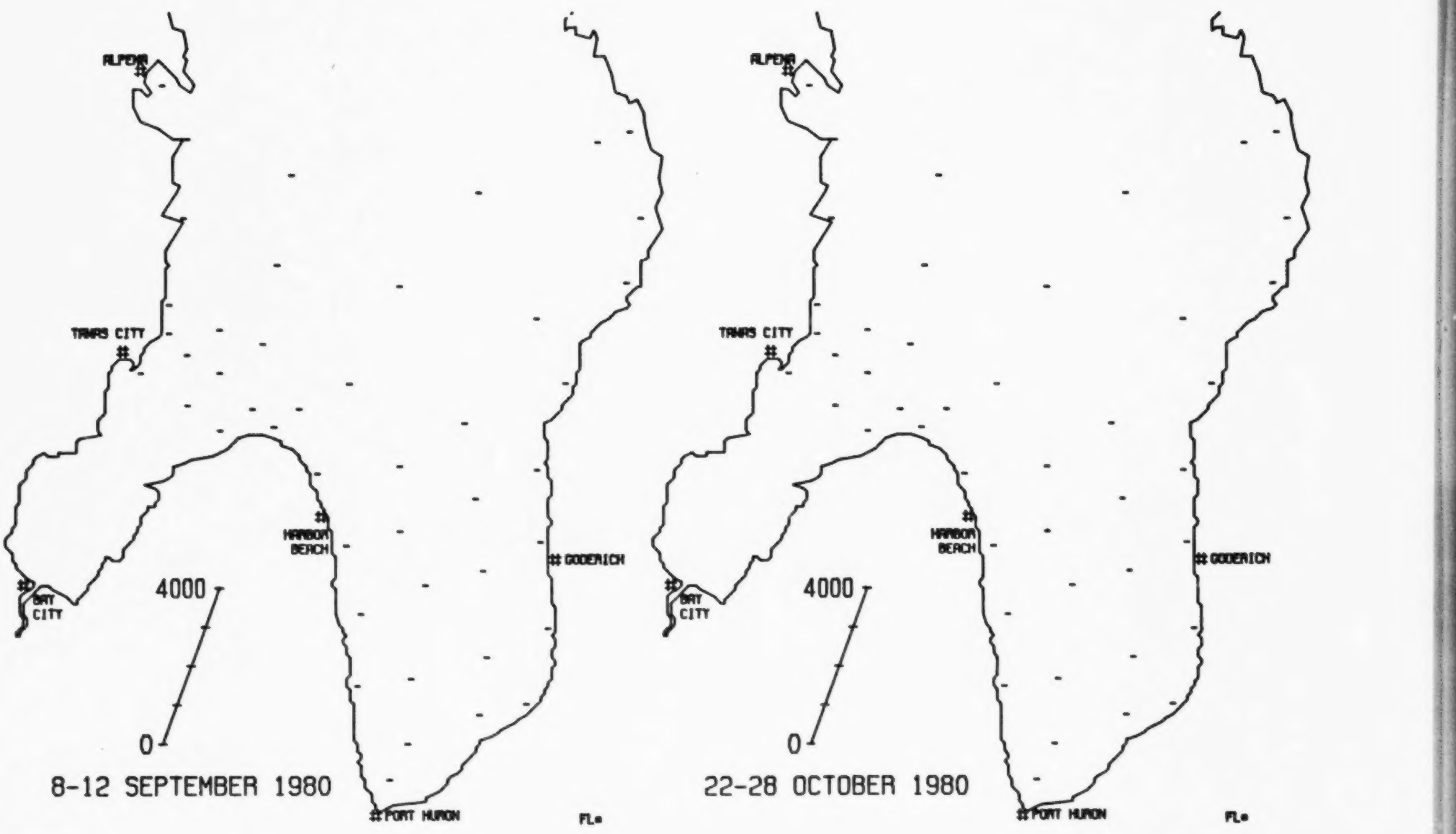
Figure 50. Distribution of Flagellate sp. #15.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
FL

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 50. (continued)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GODERICH
PORT HURON
4000
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FL=
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
4000
0
FL=

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 50. (continued)

was observed in September (fig. 51E) with highest concentrations in the lower portion of the southern basin. Elevated abundances were recorded for October (fig. 51F) with greatest abundances in the Saginaw Bay interface.

Chrysosphaerella longispina

Populations of this species were only recently recorded from the Great Lakes and are apparently most abundant in Lake Huron (Stoermer *et al*. 1976, Lowe 1976, Stoermer and Kreis 1980). It is a relatively large motile colony containing up to 640 individuals per colony. This species was not observed in southern Lake Huron until July (fig. 53A), when an isolated population was recorded in the northern Saginaw Bay interface. It reached greatest abundance and occurrence in September (fig. 53B). It was most abundant in the southern basin particularly in the extreme southern sector. Reduced concentrations were recorded for October (fig. 53C) and although was present in all sectors, it was especially abundant in the Saginaw Bay interface.

Dinobryon divergens

D. divergens is a motile, colonial form which is the most commonly reported species of this genus from the Great Lkaes. Historically, the arborescent colonies were observed in net plakton samples and led to Lake Michigan being deemed a '*Dinobryon*' lake (Ahlstrom 1936). For this study, its distribution was generally confined to the nearshore zone around the study area. The Saginaw Bay interface waters in

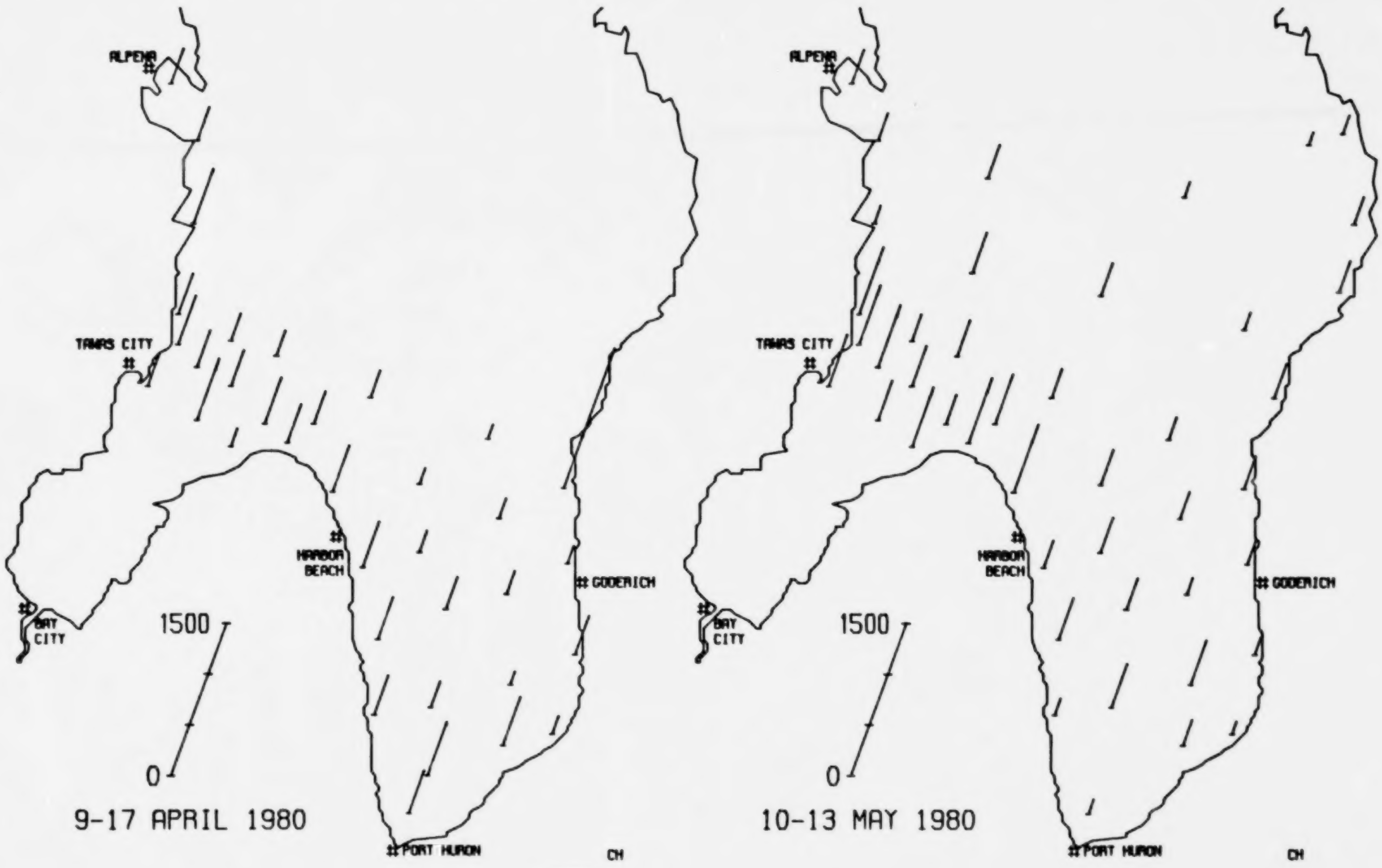
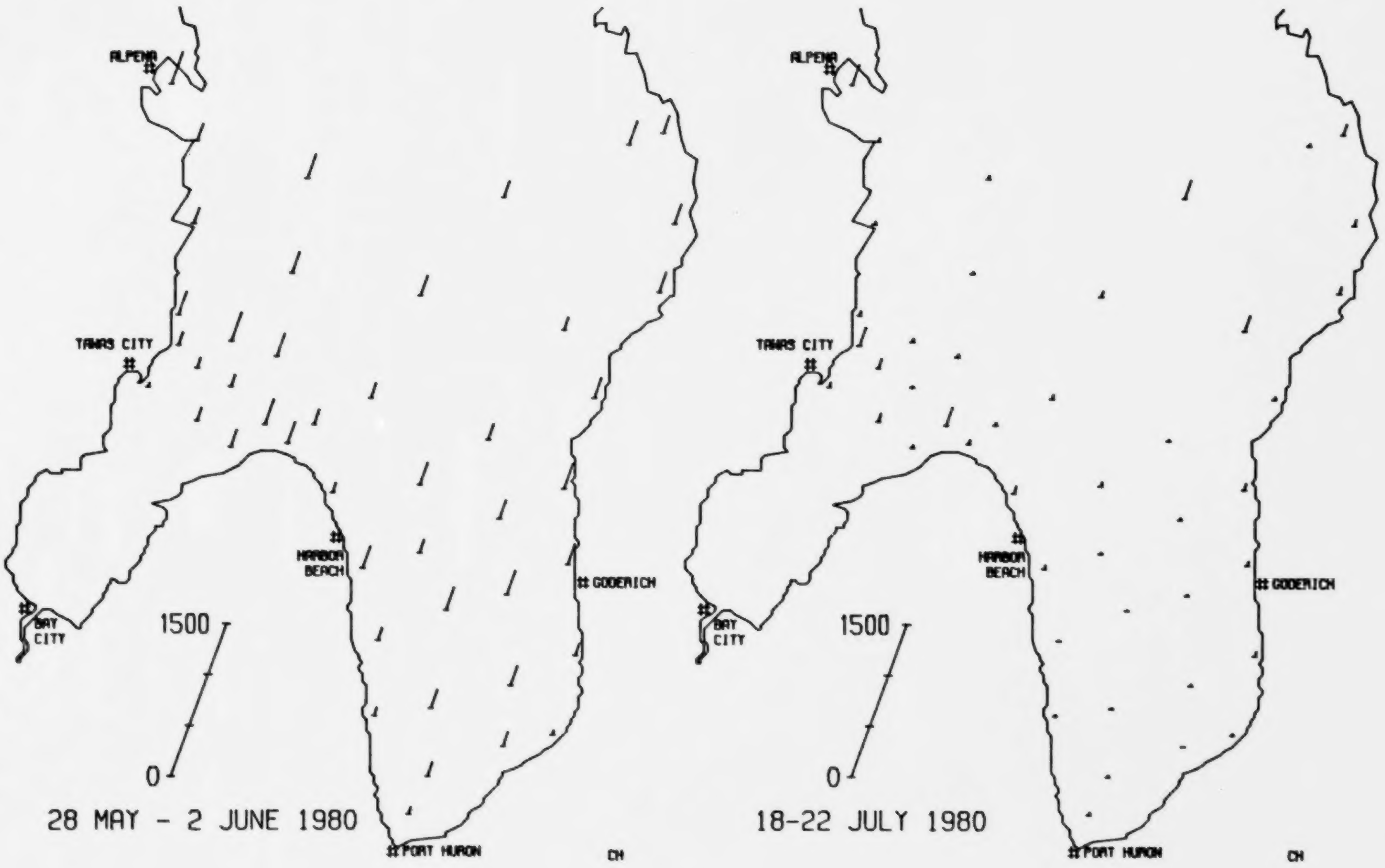

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CH
1500
0
9-17 APRIL 1980
10-13 MAY 1980

Figure 51. Seasonal distribution and abundance trends of Chrysophytes.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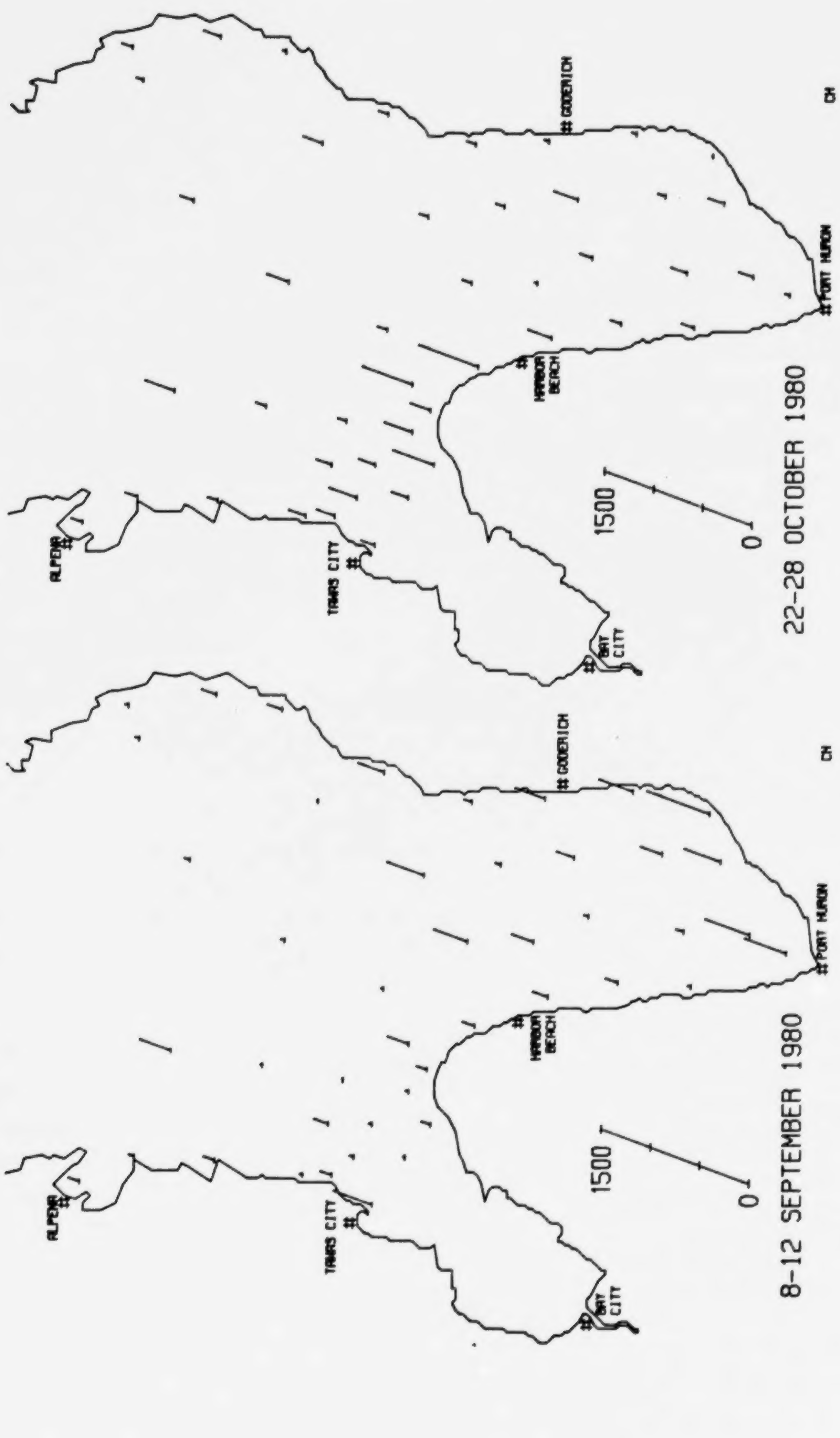
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CH
1500
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CH
1500
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 51. (continued)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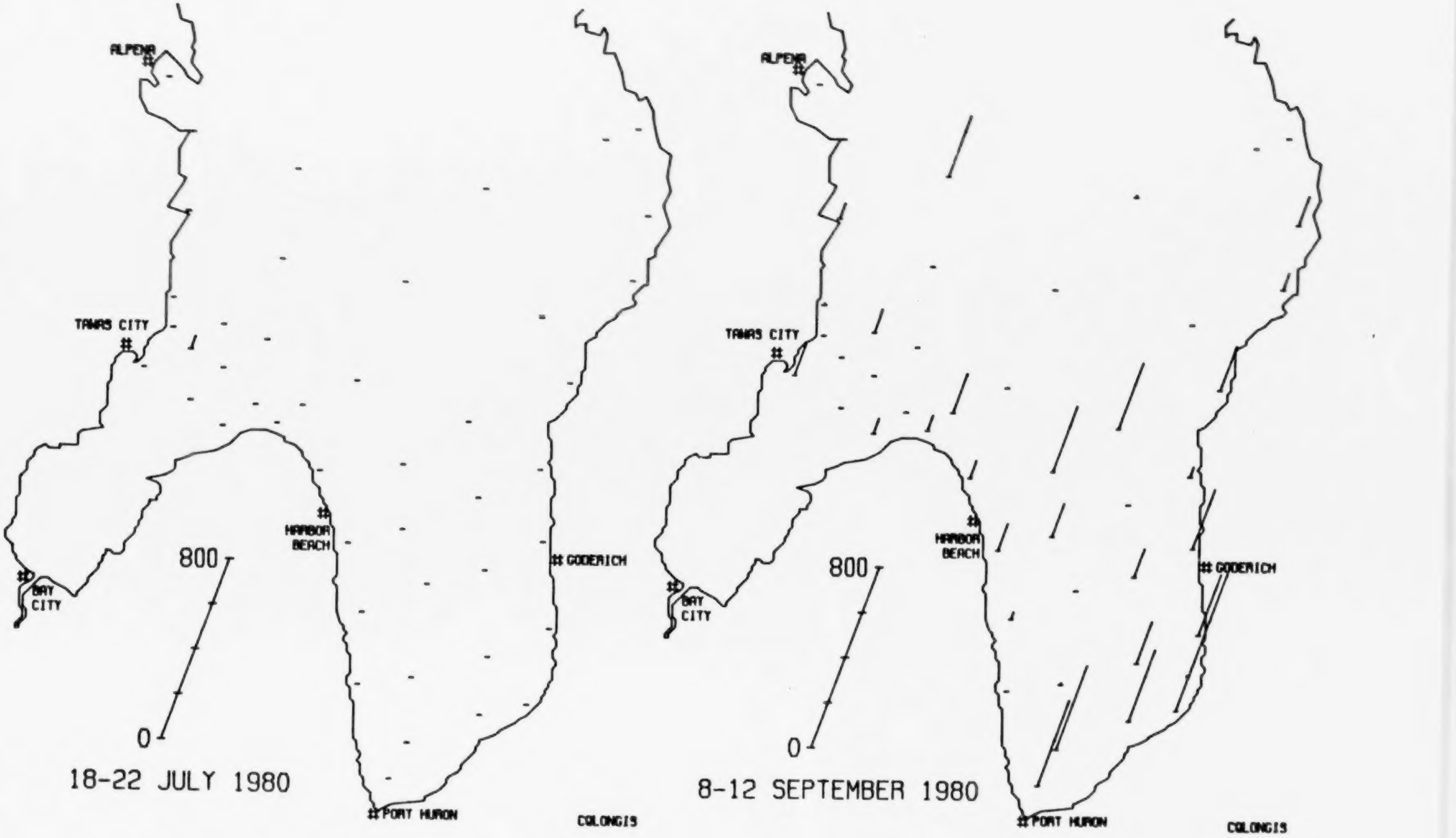
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CM
1500
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CM
1500
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 51. (continued)


18-22 JULY 1980

8-12 SEPTEMBER 1980

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BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
COLONGIS
800
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
COLONGIS
800
0

Figure 52. Distribution of Chrysosphaerella longispina.

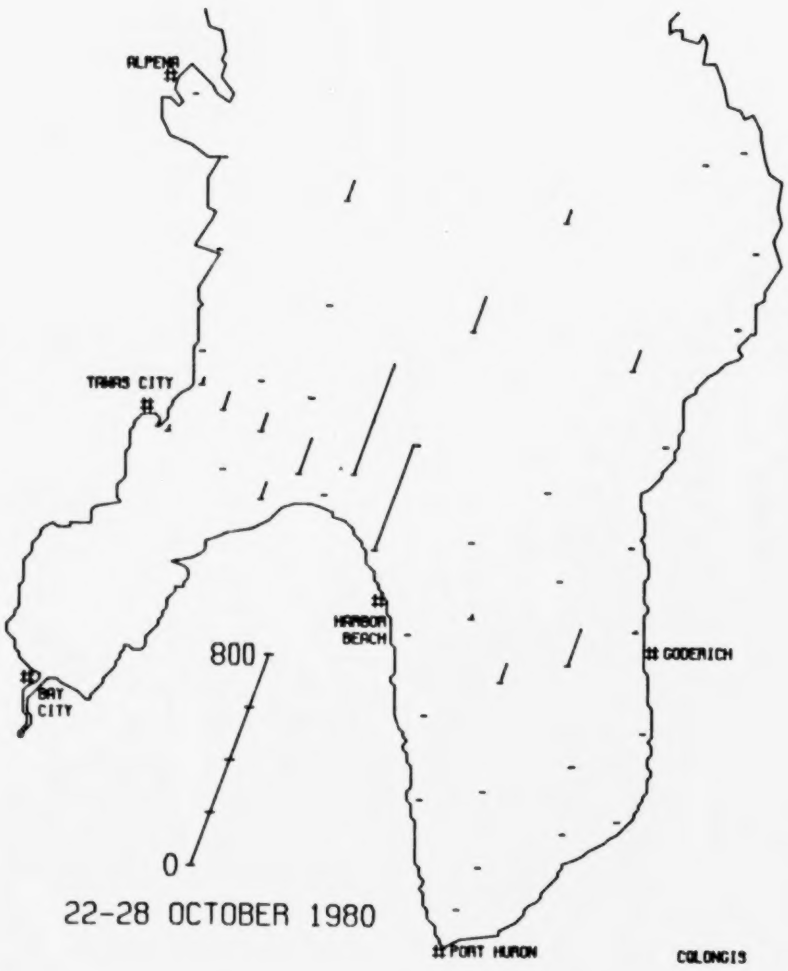

ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
COLONGIS
800
0
22-28 OCTOBER 1980

Figure 52. (continued)

April (fig. 52A), exhibited the highest abundance for the year during this sampling period. One large population was observed in the nearshore area north of Goderich. Low abundances were observed from May through July (figs. 52B - 52D) with occurrences for the most part, again, in nearshore areas and waters adjacent to Saginaw Bay. During September (fig. 52E) it was noted in nearshore areas in moderately low abundance but the occurrences were centered in the southern basin. Only sporadic occurrences at moderate abundances were seen in October (fig. 52F).

Chrysococcus dokidophorus

Very little is known about the autecology and distribution of this small, flagellate species. In April (fig. 54A) it was widely distributed in low abundances in the southern basin. Reduced abundance was observed in May (fig. 54B) revealing no apparent distributional pattern. Similarly, in June (fig. 53C) low abundances were recorded showing no distinct pattern. Elevated cell numbers, especially in the nearshore areas around the lake were observed in July (fig. 54D). It also showed a wide distribution over the entire study area. Few occurrences were observed in decreased abundance in September (fig. 53E). Populations were concentrated in the central basin and the adjacent waters of Saginaw Bay. Increased abundance and occurrence was recorded for October (fig. 53F) reaching its greatest average abundance during this sampling period. It was widespread through the study area with

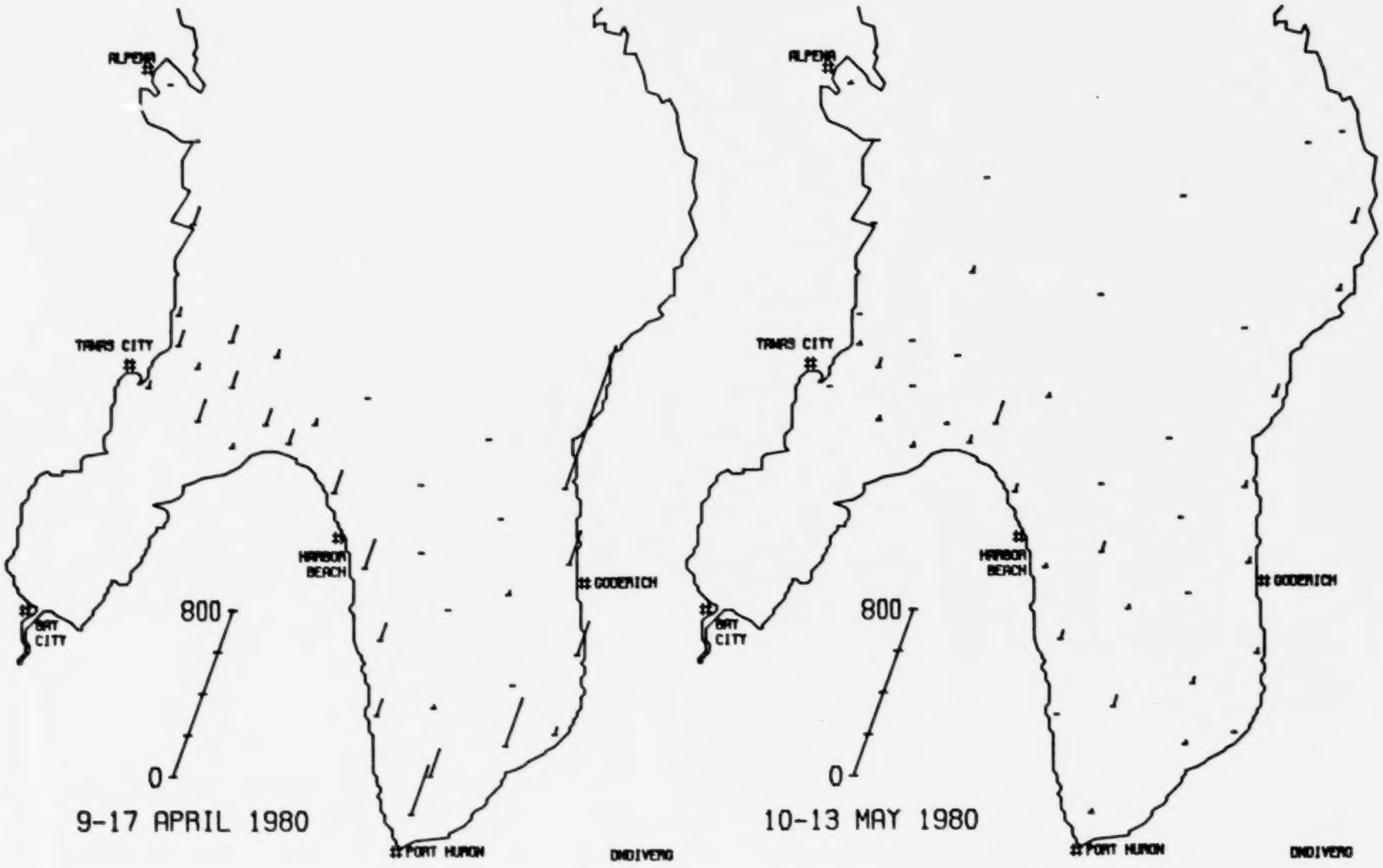
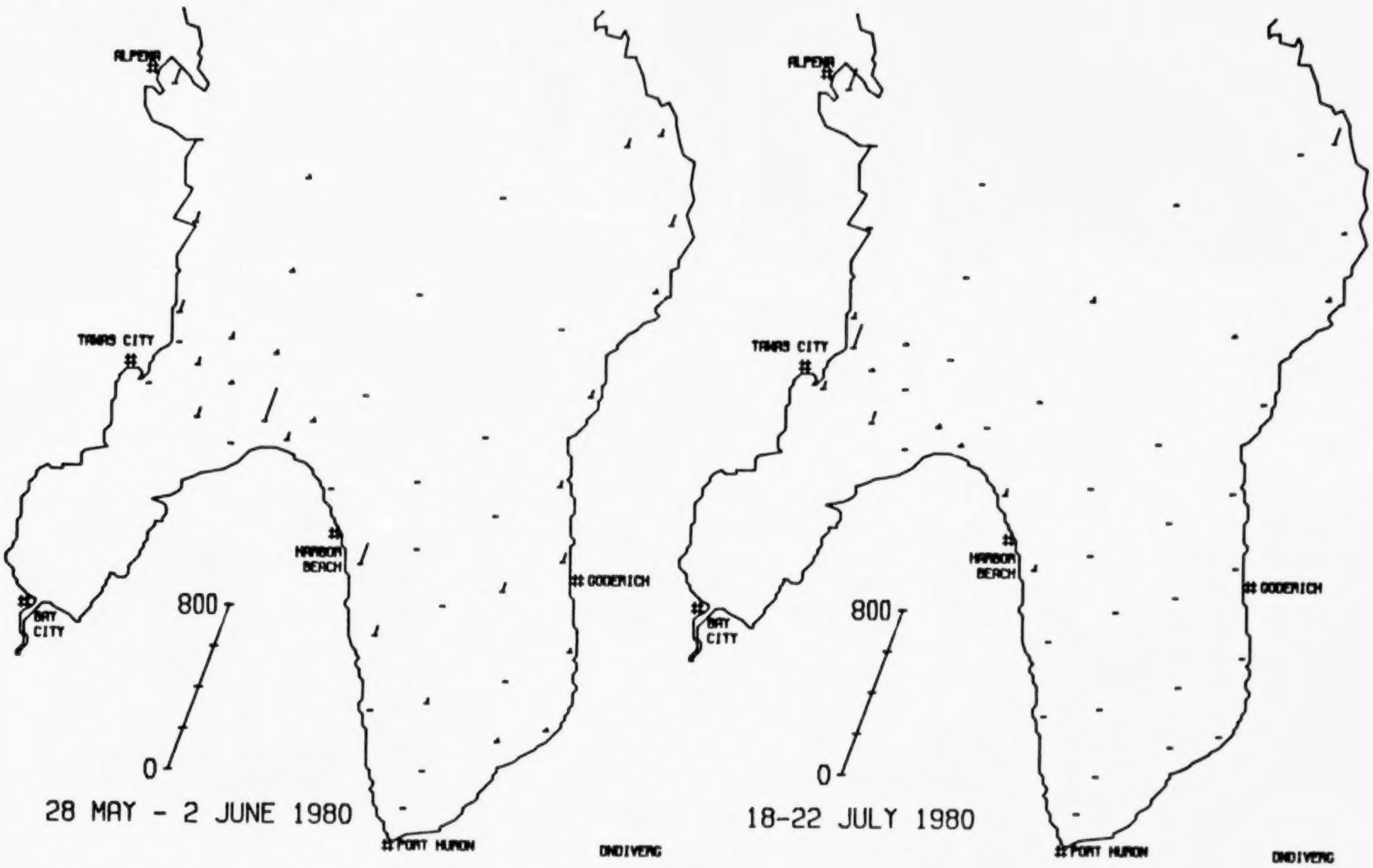

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DNDIVERG
800
0
9-17 APRIL 1980
10-13 MAY 1980

Figure 53. Distribution of Dinobryon divergens.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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DNDIVERG
800
0
28 MAY - 2 JUNE 1980
ALPENA
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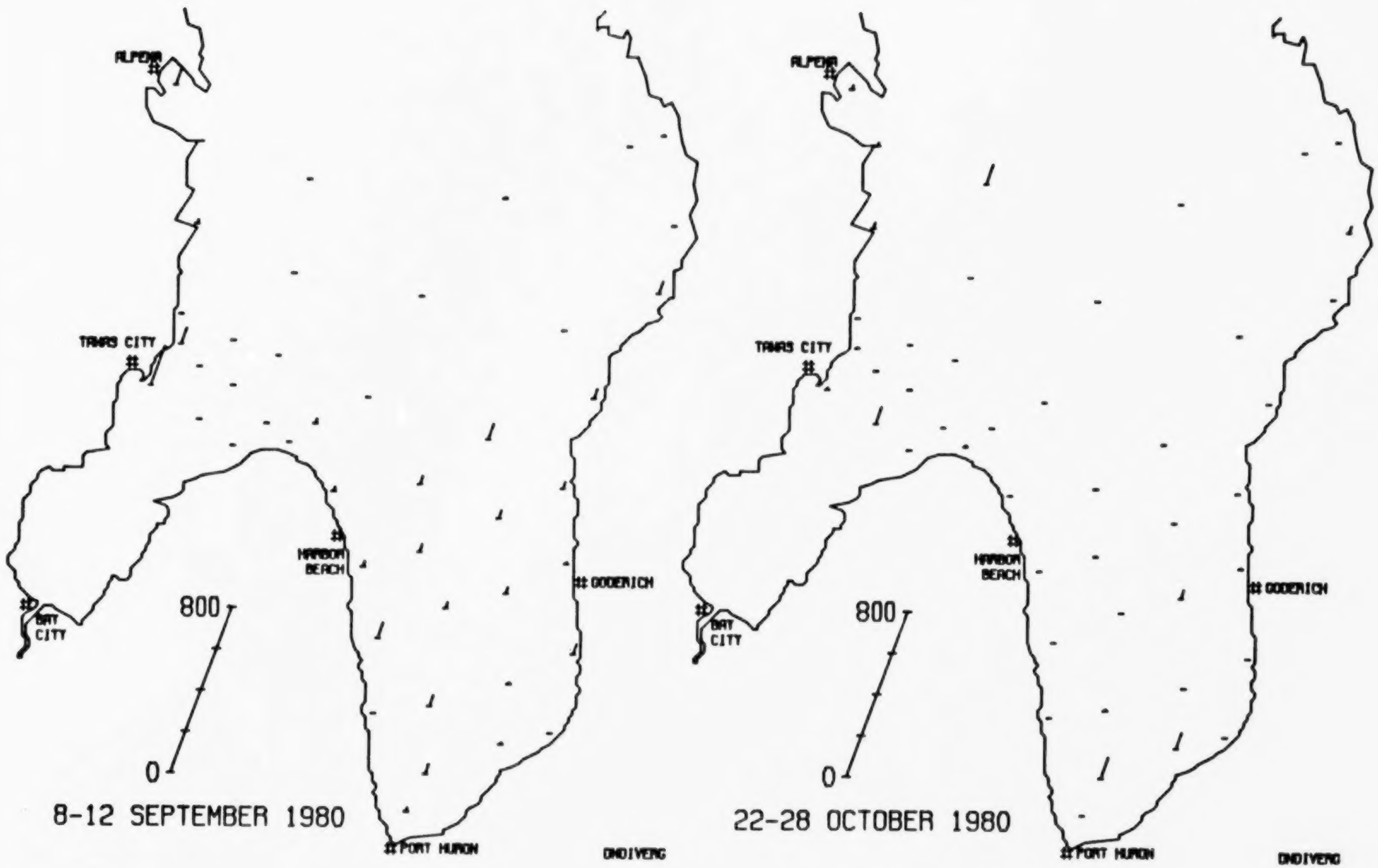
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DNDIVERG
800
0
18-22 JULY 1980

Figure 53. (continued)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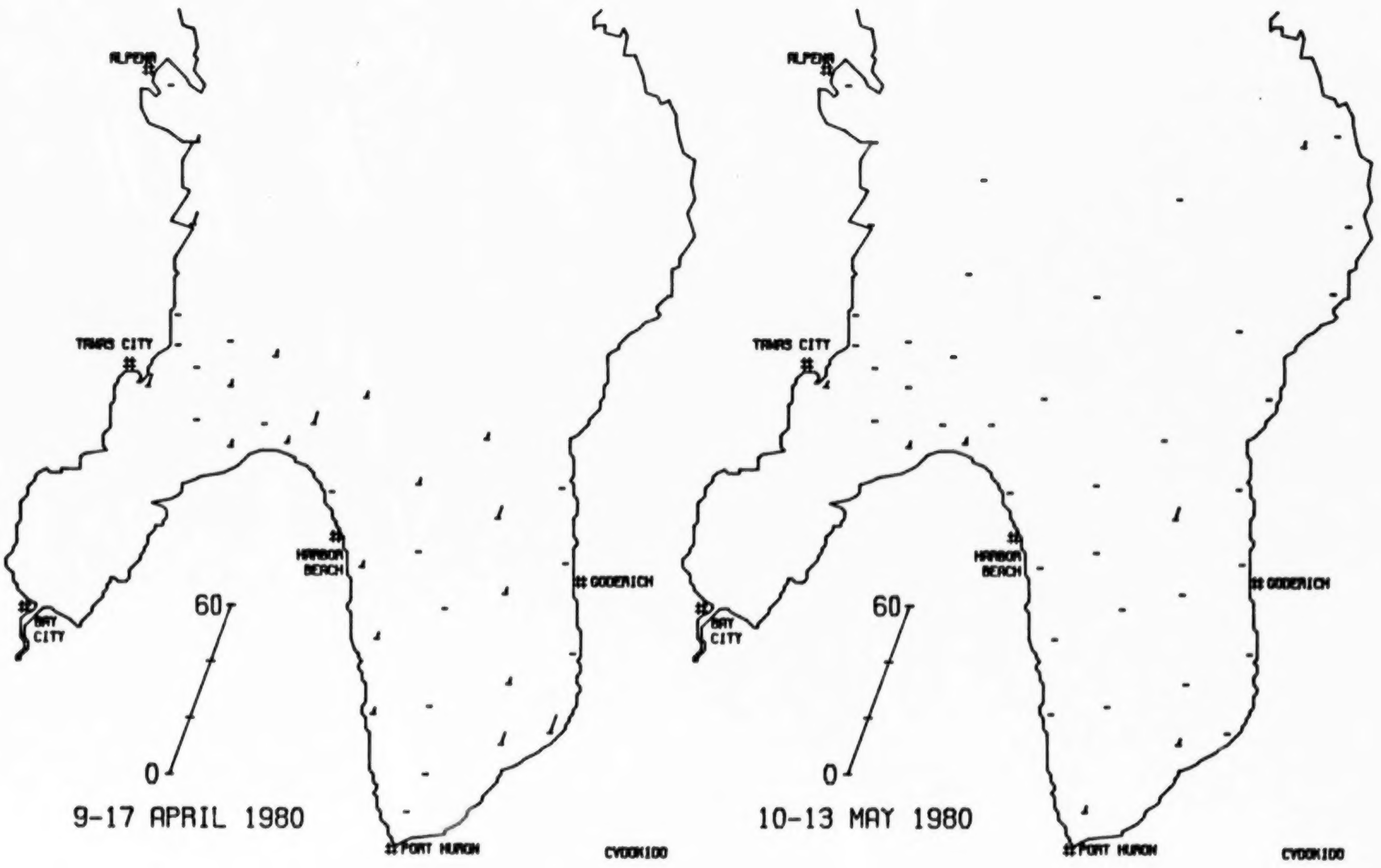
PORT HURON
GODERICH
800
0
CNDIVERG
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
800
0
CNDIVERG

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 53. (continued)

largest abundances in the southern basin and generally in offshore waters.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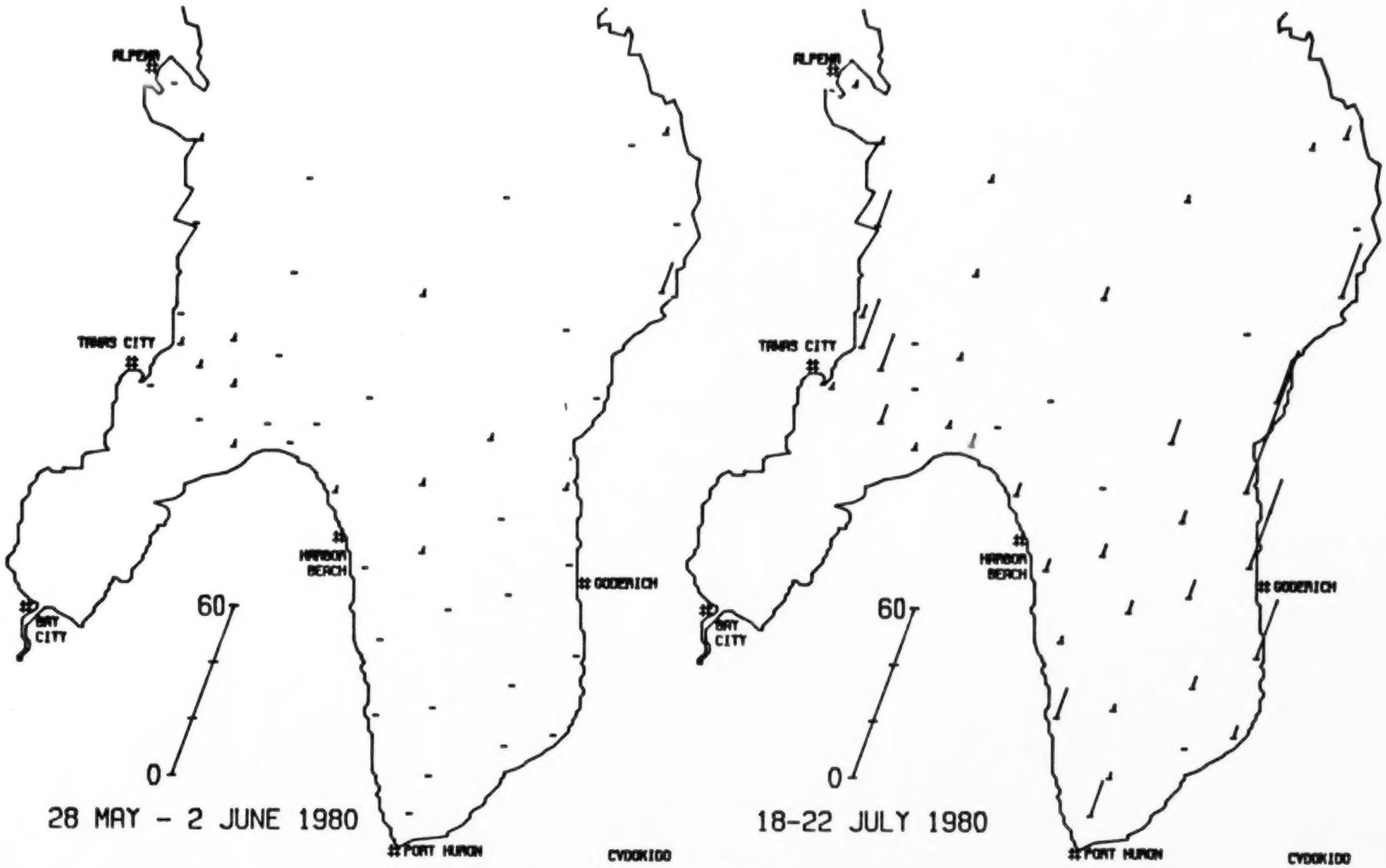
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CVDOKIDO
60
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CVDOKIDO
60
0

9-17 APRIL 1980

10-13 MAY 1980

Figure 54. Distribution of Chrysococcus dokidophorus.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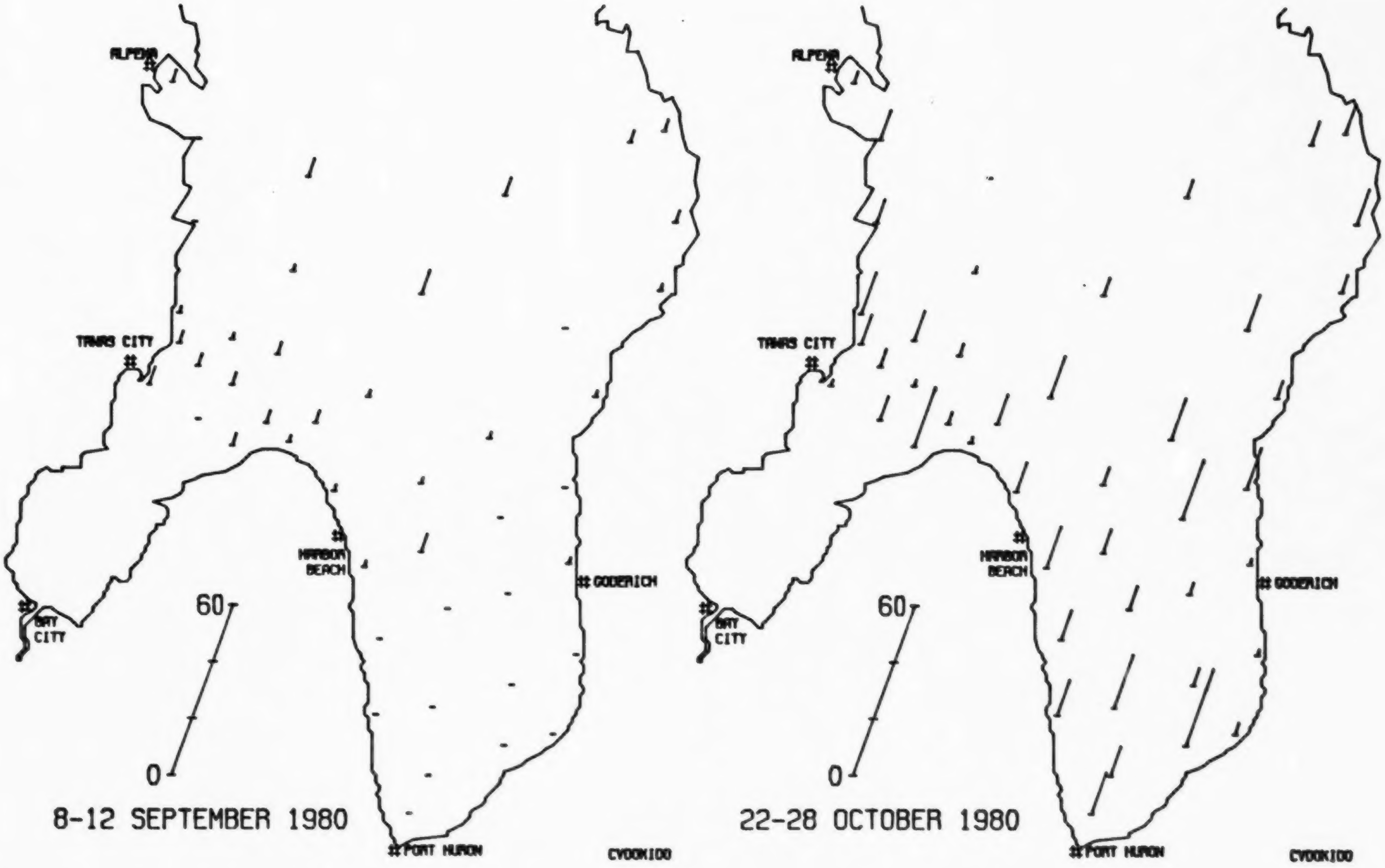
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CVDOKIDO
60
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CVDOKIDO
60
0
18-22 JULY 1980

Figure 54. (continued)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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
CVOOKIDO
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
CVOOKIDO

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

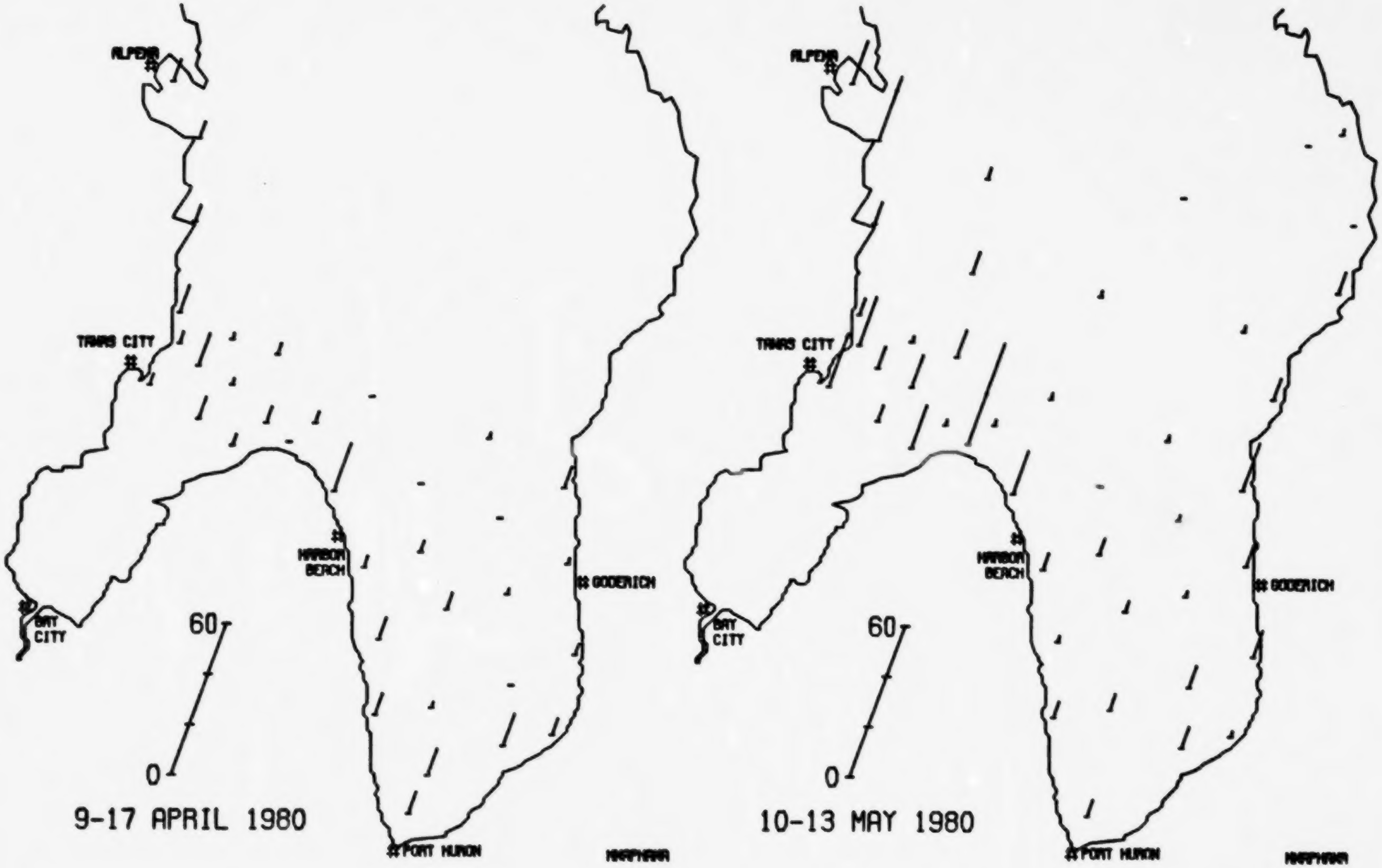
Figure 54. (continued)

Monochrysis aphanaster

This chrysophyte has not been previously reported from the Great Lakes, although it was commonly found during this study. In April (fig. 55A) moderate abundances were observed, and it was widely distributed over the study area. During May (fig. 55B) populations were most abundant in the Saginaw Bay interface zone and near Alpena. In June (fig. 55C) higher abundances were observed and were particularly concentrated in the nearshore zones around the study area as well as in the Saginaw Bay interface. In July (fig. 55D) it was widely distributed at comparatively low abudnances, exhibiting highest standing crops in the mid-central basin. In September (fig. 55E) it occurred in all sectors of the lake at low abundaces however showing no apparent distributional trends. Highest concentrations were observed in the U.S. nearshore area for October (fig. 55F) but was observed throughout the study area.

Ochromonas sp. #2

This small flagellate form has not been satisfactorily aligned with a described species. On average, it was the most abundant chrysophyte observed in the study area and exhibited a bimodal abundance periodicity. It was previously reported from Lake Huron as Ochromonas sp. #1 (Stoermer and Kreis 1980). In April (fig. 56A) it was widely distributed over the entire study area . Highest abundances were seen between Alpena and Tawas City in the nearshore zone, outer Saginaw Bay and in large abundance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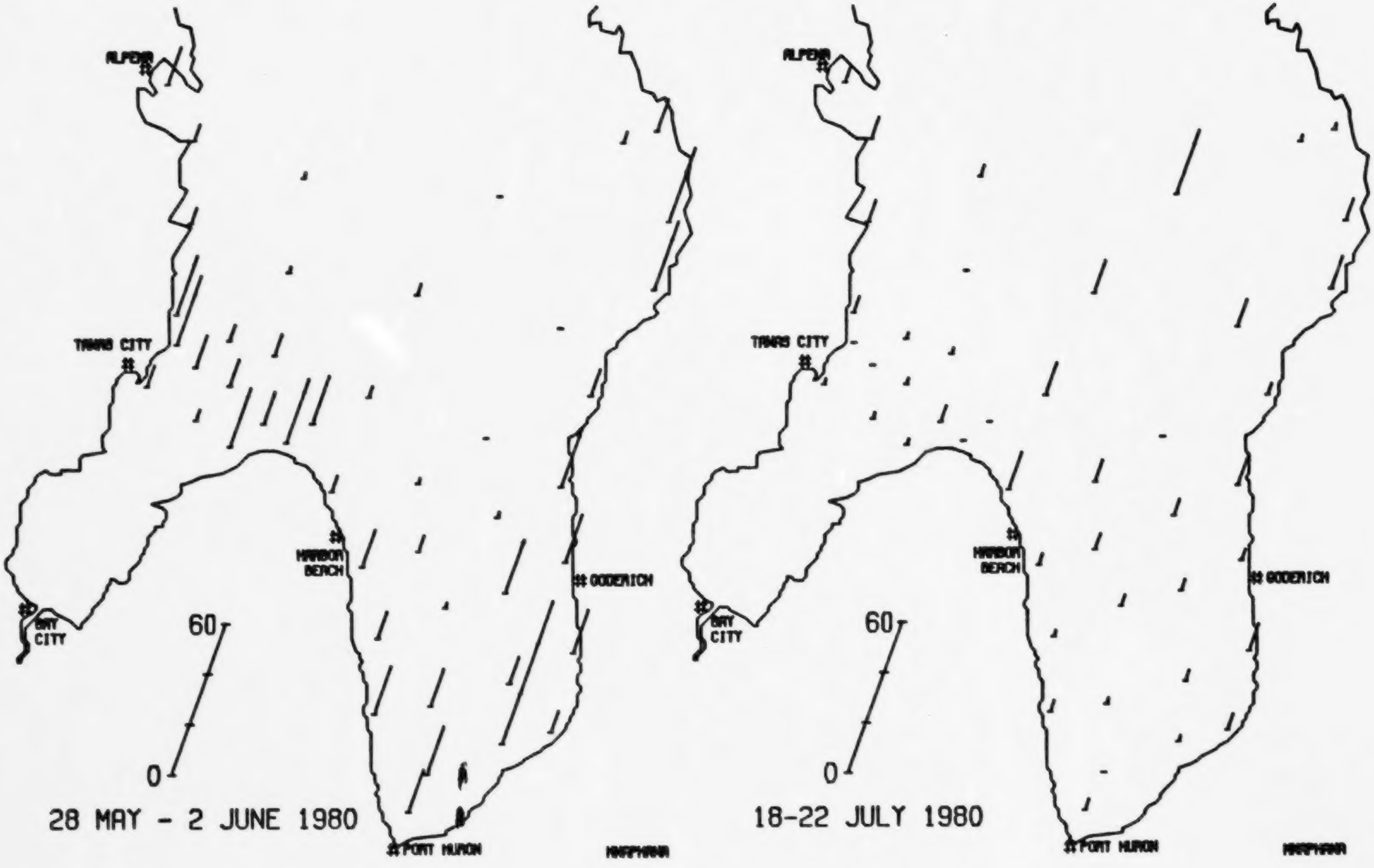
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
9-17 APRIL 1980
MNAPHANA
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
10-13 MAY 1980
MNAPHANA

Figure 55. Distribution of Monochrysis aphanaster.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 55. (continued)

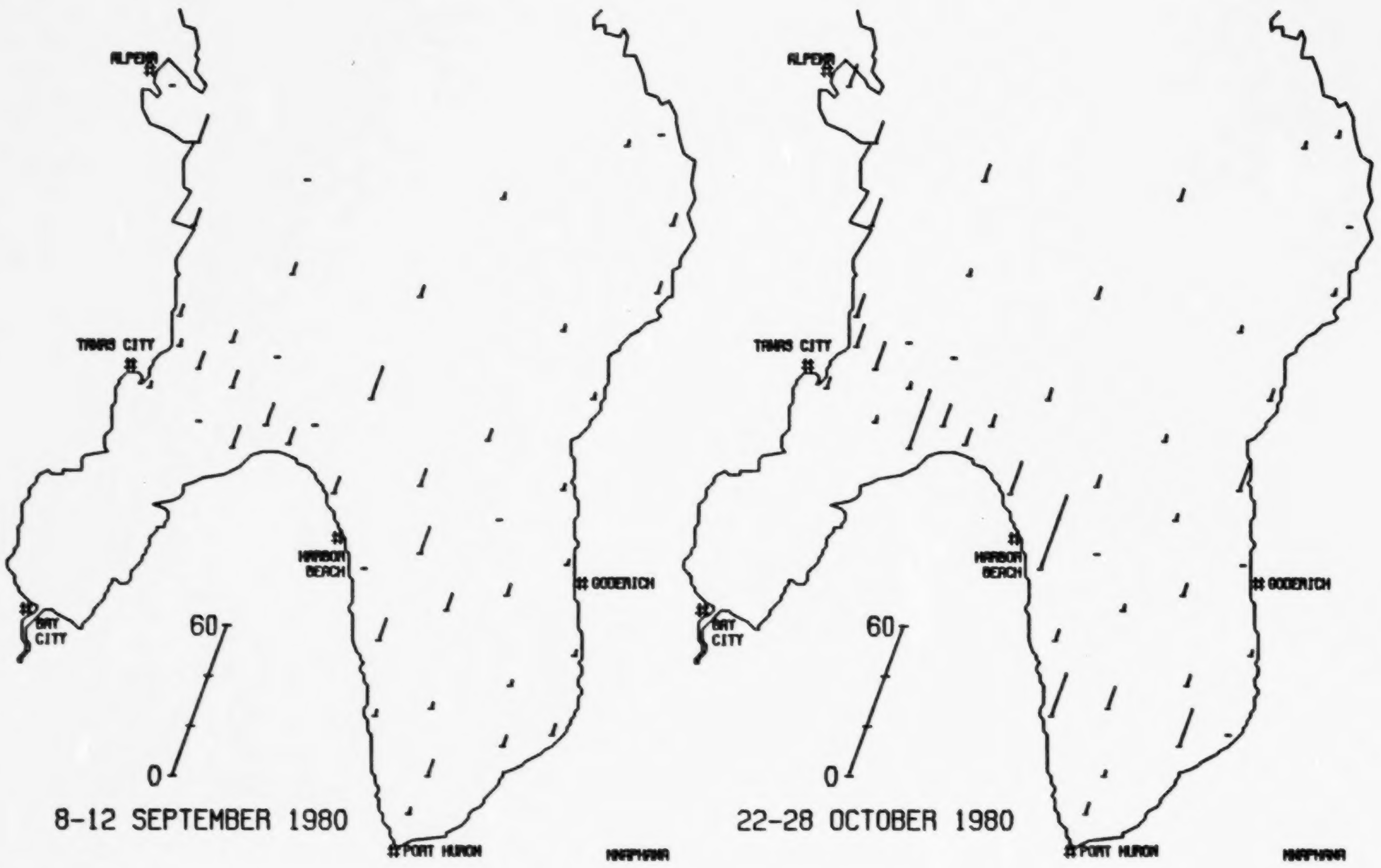
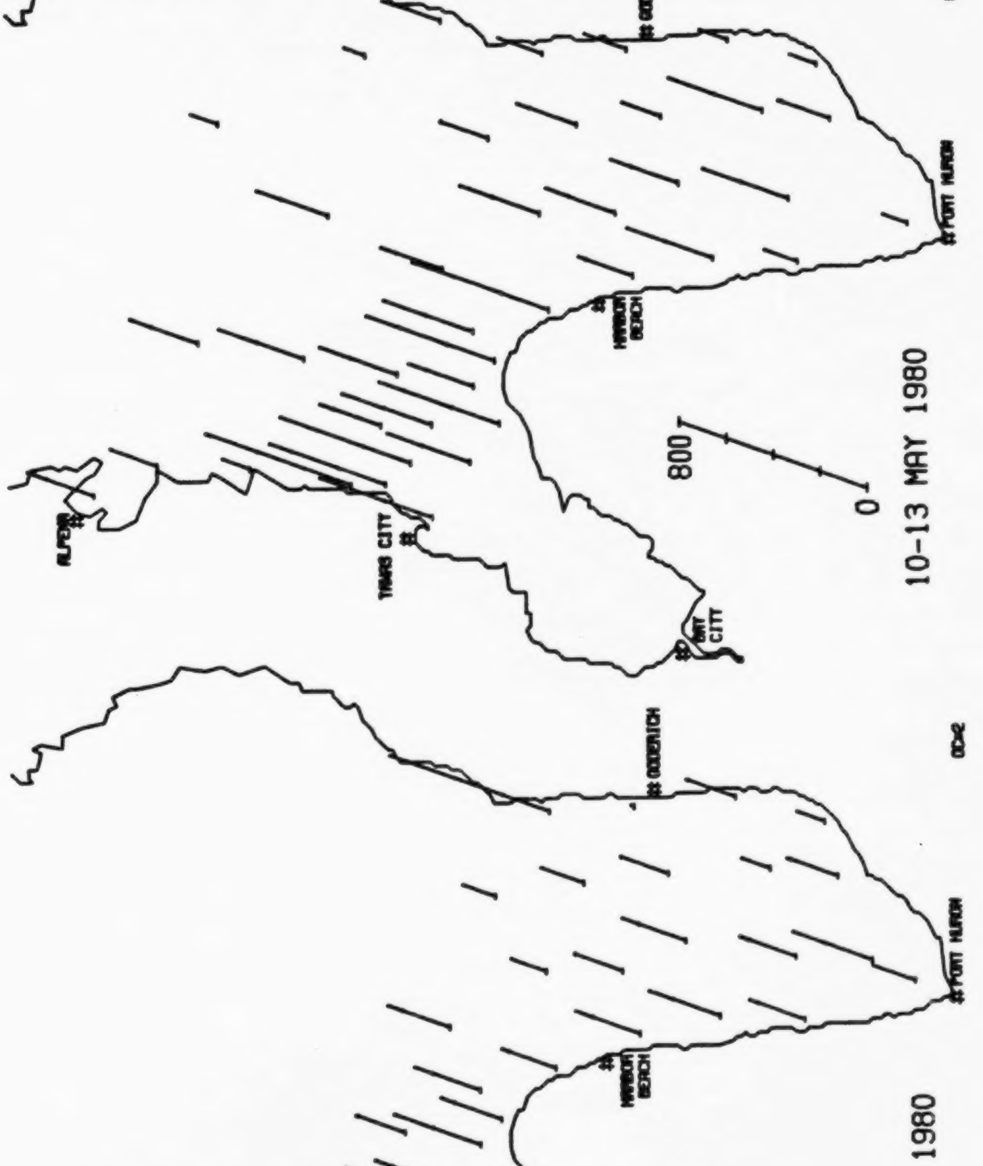

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
60
0
8-12 SEPTEMBER 1980
22-28 OCTOBER 1980

Figure 55. (continued)

north of Goderich. During May (fig. 56B) it was again well represented over the study area with greatest cell numbers in Saginaw Bay and adjacent waters. Reduced abundances were observed in June (fig. 56C), particularly along the southern U.S. shore and in Saginaw Bay. Greatest cell densities were recorded in the offshore waters of the central basin. During July (fig. 56D) populations had been reduced and were seen in very low abundances in the offshore central basin. During September (fig. 56E) few or no occurrences were recorded. Modest abundance was observed in October (fig. 56F) with highest cell counts occuring in outer Saginaw Bay and the interface zone.

CRYPTOPHYTA - CRYPTOMONADS

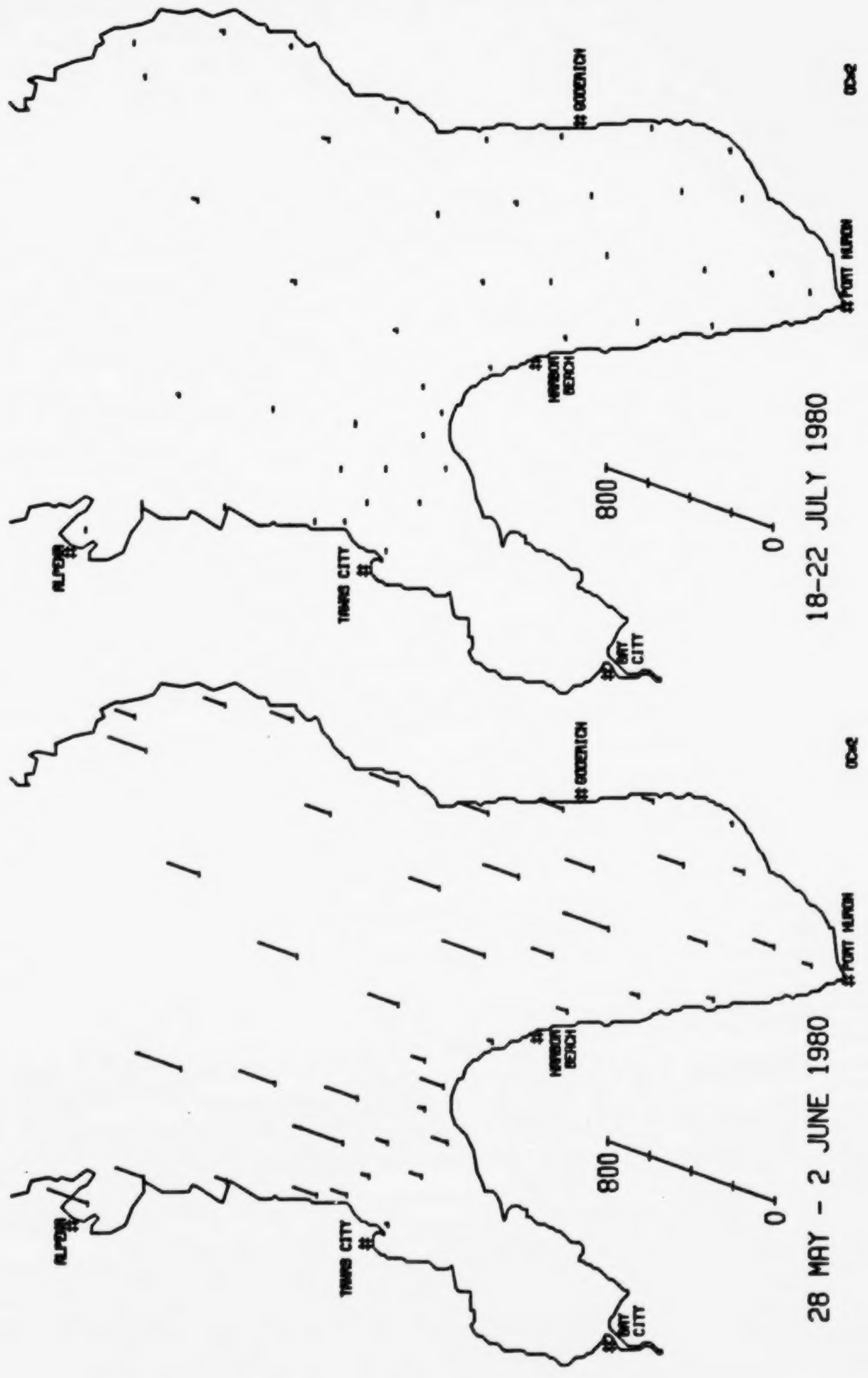
Some element of this flagellate group is usually present in any collection from the Great Lakes. Cryptomonads were present during all sampling periods in southern Lake Huron. They generally are found in greatest abundance in nutrient enriched areas however most species can be observed in areas ranging anywhere from eutrophic to oligotrophic (Huber-Pestalozzi 1968). This is particularly evident in the Great Lakes. In a number of cases, what appears to be the same species is reported from Lake Erie as well as from Lake Superior (Munawar and Munawar 1976, Munawar and Munawar 1978). In southern Lake Huron, cryptomonads show a seasonal cycle but are still evenly distributed throughout the study area. During April (fig. 57A) abundance was moderate and uniformly distributed


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
OC-2
800
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
OC-2
800
0

9-17 APRIL 1980

10-13 MAY 1980

Figure 56. Distribution of *Ochromonas* sp. #2



ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
OC-2
800
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
OC-2
800
0

18-22 JULY 1980

28 MAY - 2 JUNE 1980

Figure 56. (continued)

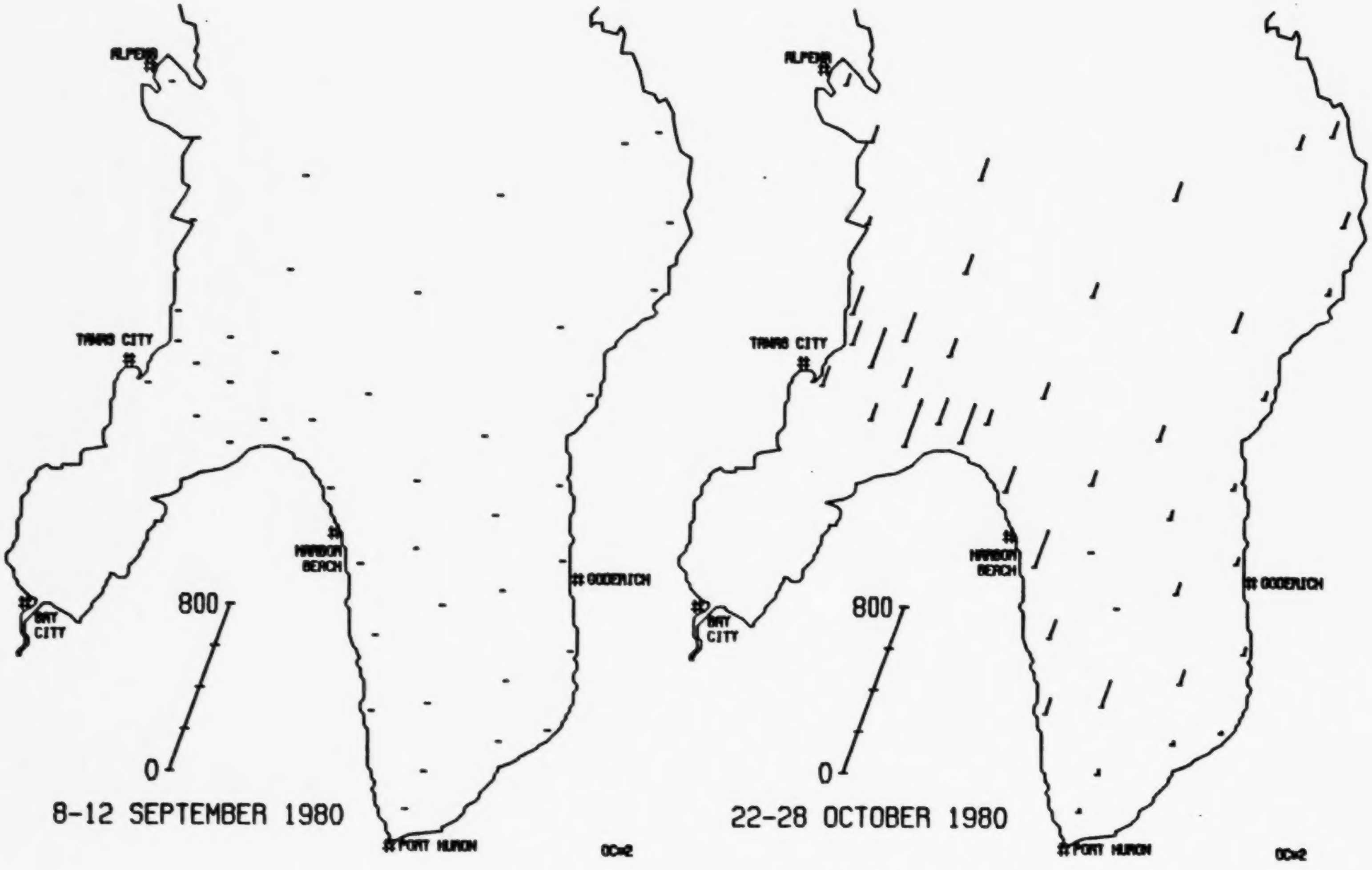

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
800
0
8-12 SEPTEMBER 1980
OC=2
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
800
0
22-28 OCTOBER 1980
OC=2

Figure 56. (continued)

over the study area. Increased abundances were recorded in May (fig. 57B) comprising the highest values for the season. Greatest abundance was observed along the Canadian coastal zone in the southern basin with slightly less concentrations in Saginaw Bay and adjacent waters. In general, abundance was lower in the central basin compared to the southern. Abundance was reduced slightly in June (fig. 57C). Distribution was generally uniform, excepting low values in the Canadian nearshore zone where abundance was high in the preceding sampling period. Reduced abundance and the lowest abundance for the year was seen in July (fig. 57D) Abundances were centered in the offshore waters of both basins. In September and October (figs. 57E and 57F) cryptomonads slightly increased and were widely distributed with the lowest abundance again, in nearshore areas.

Cryptomonas ovata

This species is one of the larger and more commonly reported cryptomonads in the Great Lakes. It has a worldwide distribution being recorded from different habitats which encompass the entire range of the trophic spectrum (Huber-Pestalozzi 1968). It has been recorded from all of the Great Lakes (Munawar 1975) but may find its greatest abundance in areas which are enriched. In April (fig. 58A) this species was fairly , uniformly distributed throughout the southern basin but showed a very large peak in the nearshore zone north of Goderich. In May (fig. 58B) highest cell numbers were seen in Saginaw Bay and in the waters just

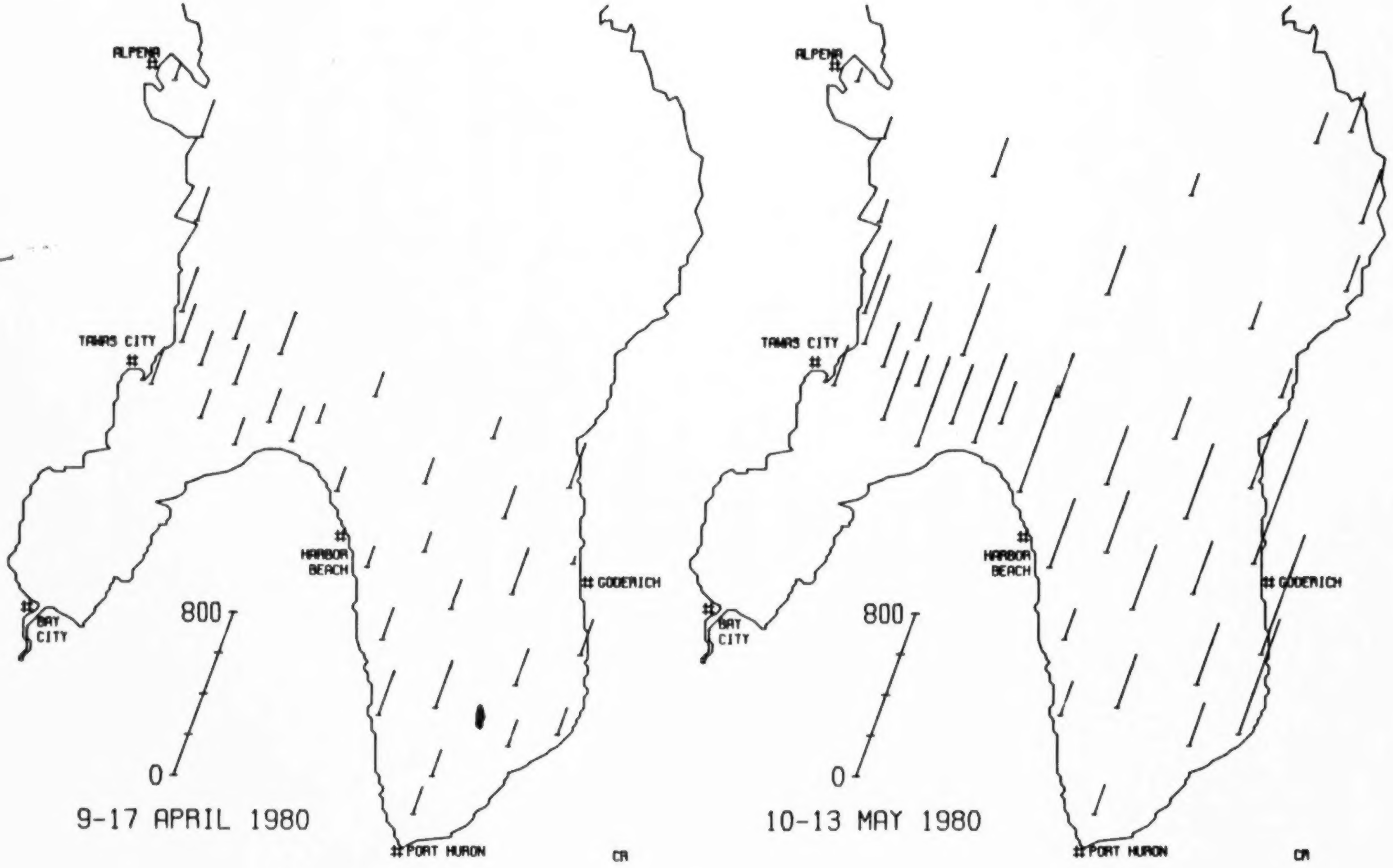
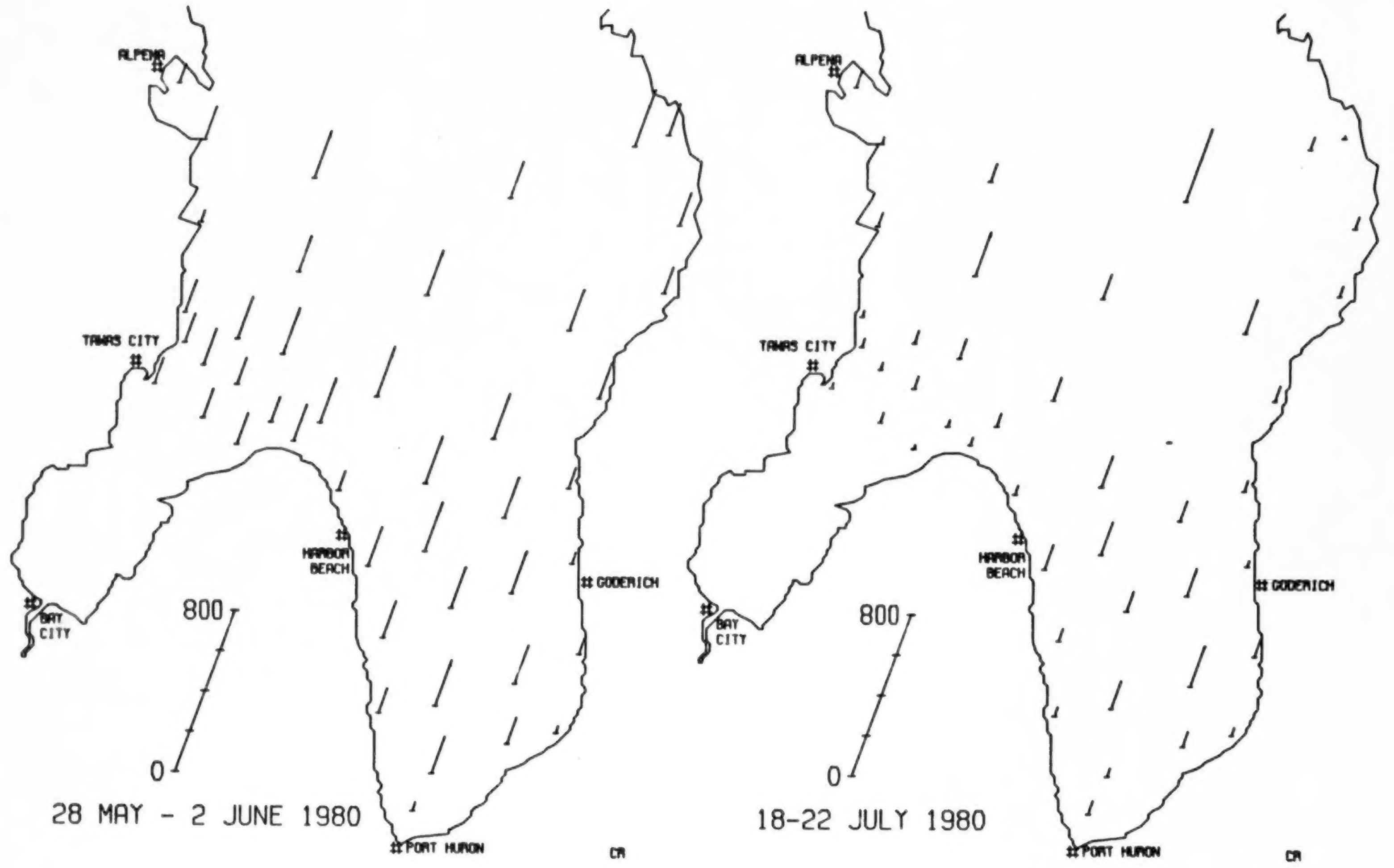

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CR
800
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CR
800
0
10-13 MAY 1980

Figure 57. Seasonal distribution and abundance trends of Cryptomonads.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CA
800
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CA
800
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 57. (continued)

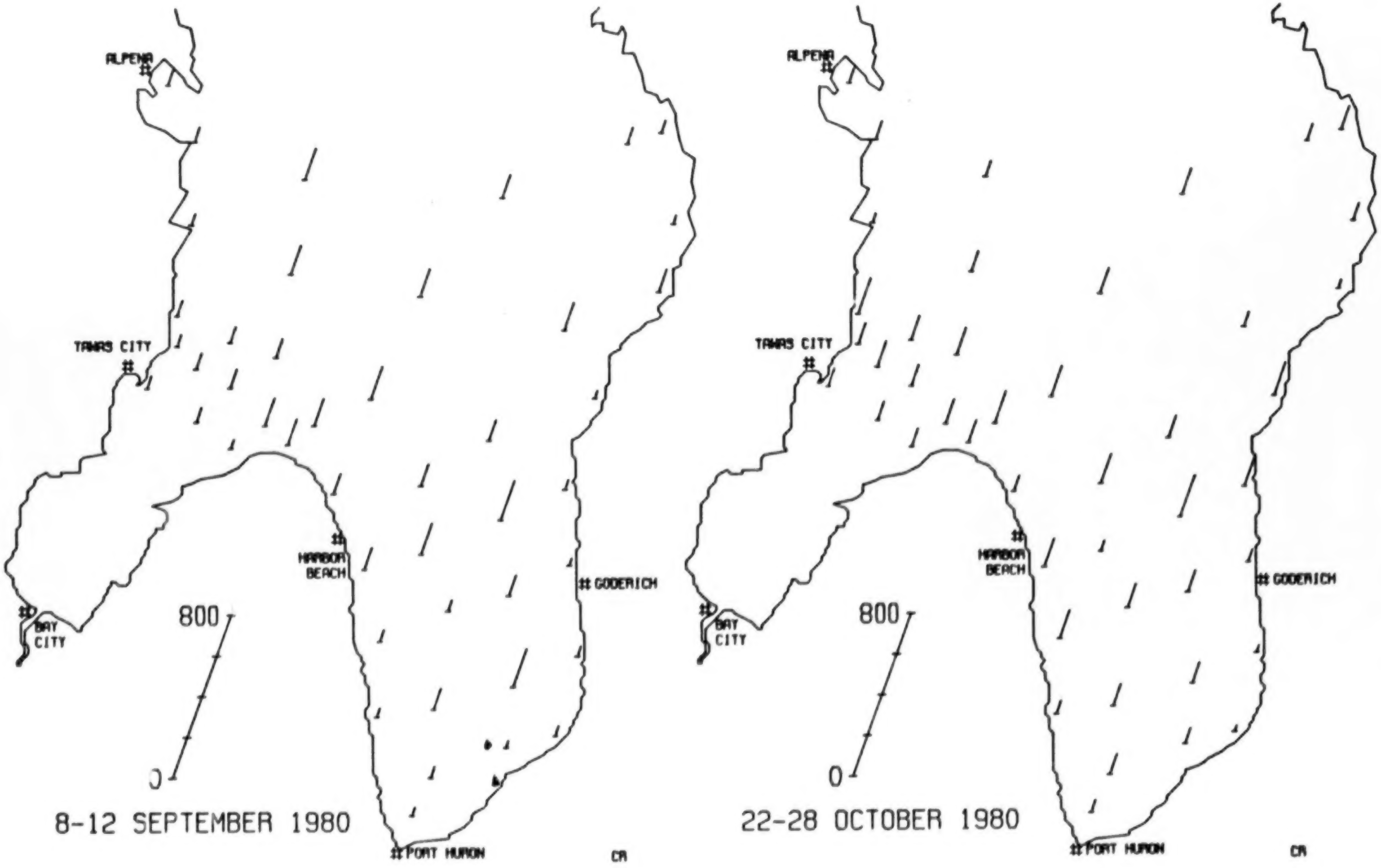

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CA
800
0
8-12 SEPTEMBER 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CA
800
0
22-28 OCTOBER 1980

Figure 57. (continued)

south of the bay, although distribution during this month was sporadic. Somewhat reduced abundances were observed in June and July (figs. 58C and 58D) showing very erratic distribution patterns. Slightly increased abundance was recorded for September (fig. 58E) and October (fig. 58F). Distinct occurrence patterns were not evident in either month, however, highest abundances were seen in October, north of Tawas City and in the open waters east of Saginaw Bay.

Chroomonas spp.

Chroomonas is a flagellate genus which has only recently received adequate taxonomic attention in the Great Lakes. Most of the forms placed in this category can be best assigned to *Chroomonas nordstedtii*. In April (fig. 59A) low abundance was observed with slightly higher abundances recorded in the nearshore zone south of Alpena and in the Saginaw Bay interface. It was well distributed in low cell numbers in the southern basin. In May (fig. 59B) highest abundances for the season were recorded. Although widely distributed over the study area, greatest abundances were in the nearshore zones of the southern basin and in Saginaw Bay with distincly less abundance in the central basin. In June (fig. 59C) lower standing crop values were observed. Highest abundances were found in the southern basin and in the Saginaw Bay interface zone. Conversely, in July (fig. 59D) highest cell numbers were seen in the offshore waters of the central basin, however it

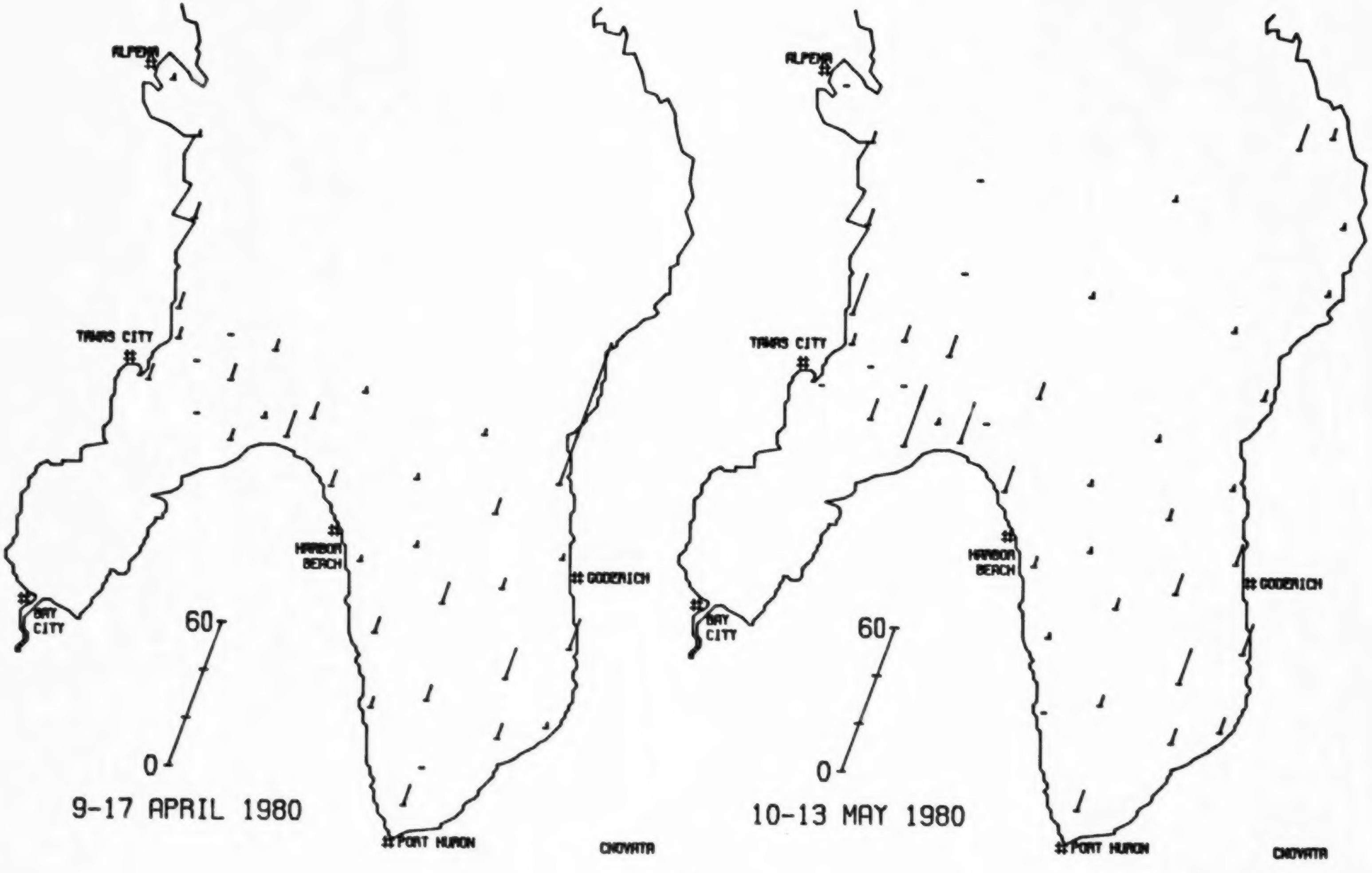
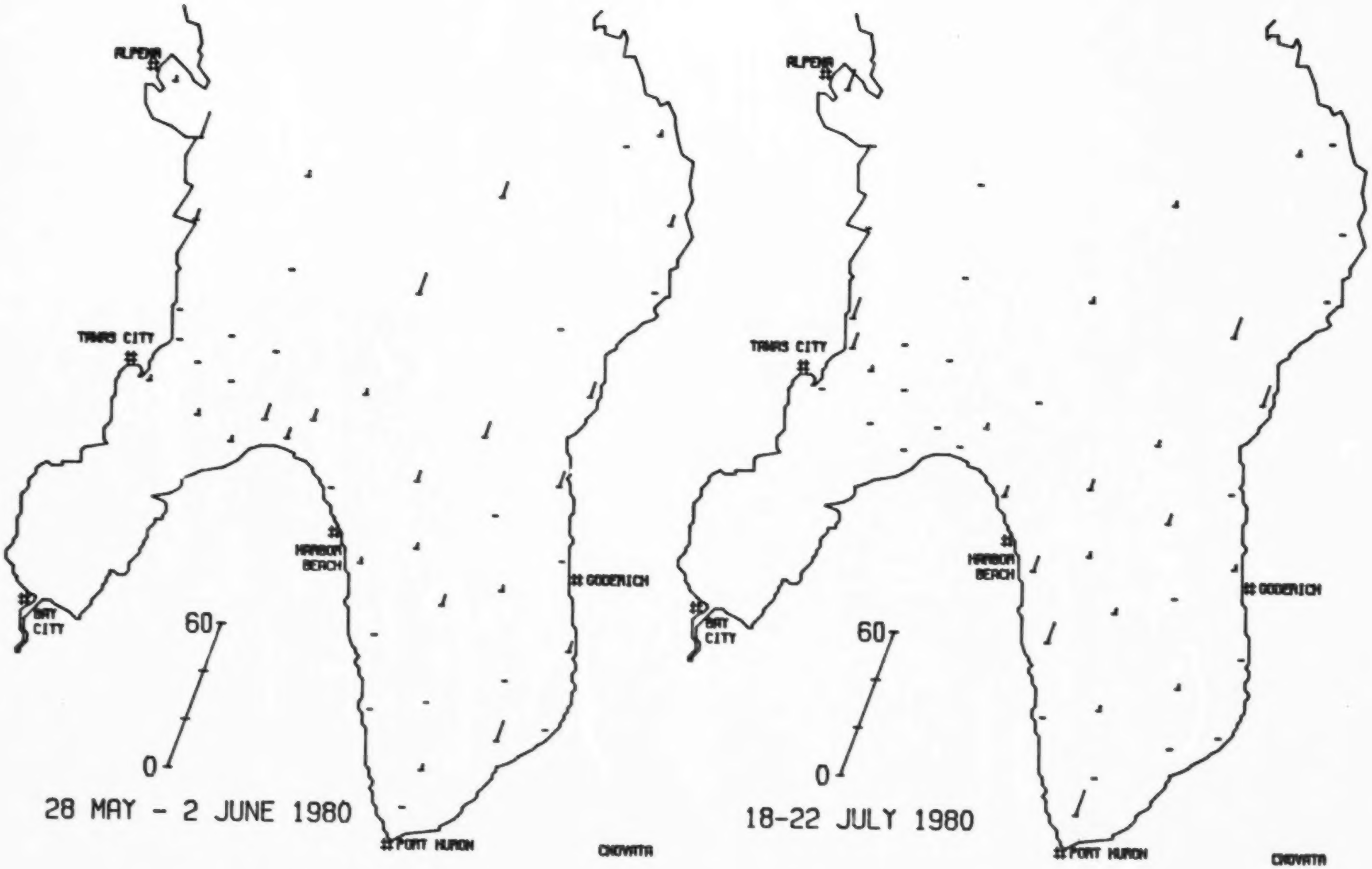

ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
CROVATA
60
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
CROVATA
60
0
10-13 MAY 1980

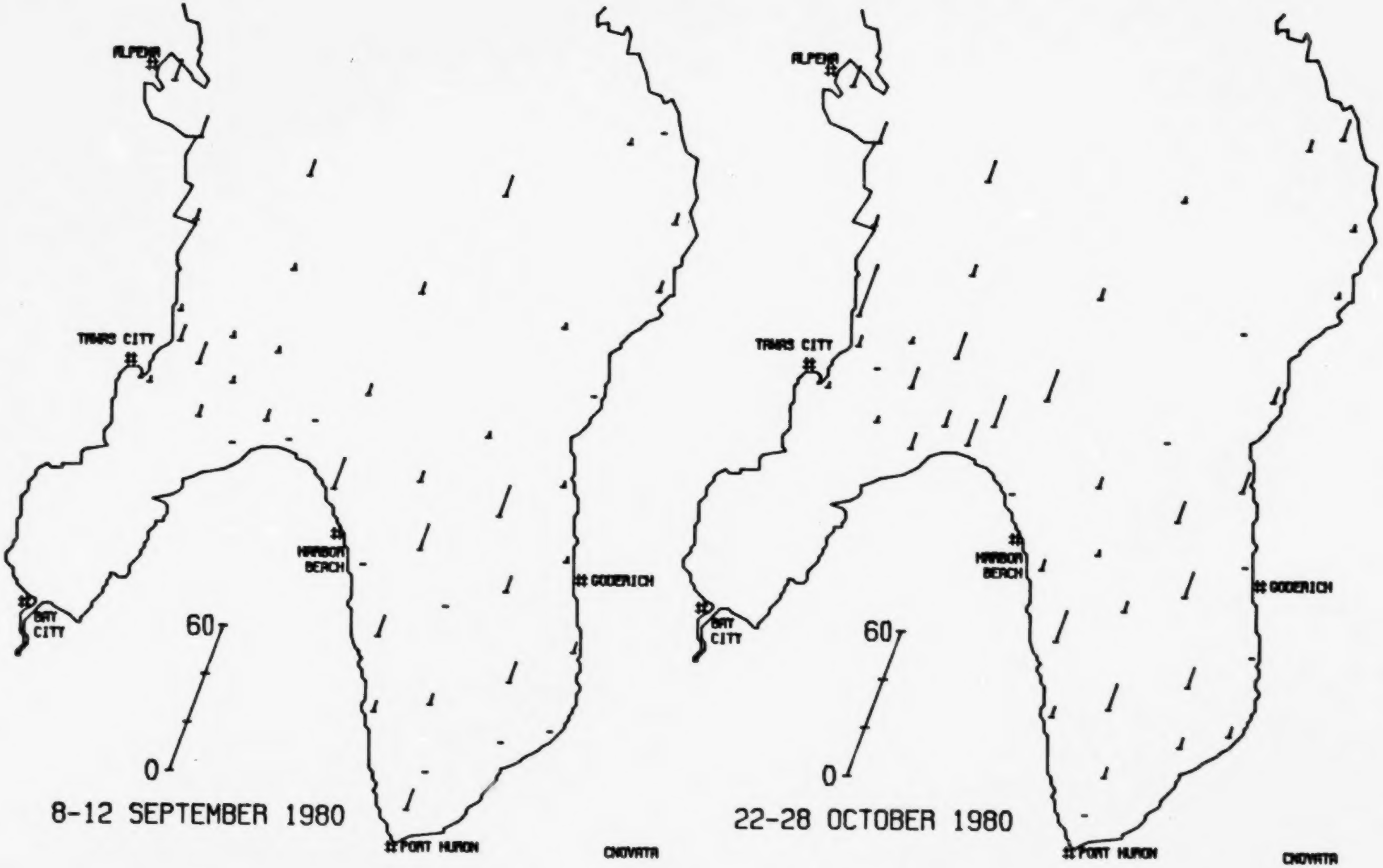
Figure 58. Distribution of Cryptomonas ovata.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CHOVATA
60
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
CHOVATA
60
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 58. (continued)


8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CNOVATA
60
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
CNOVATA
60
0

Figure 58. (continued)

was still widely distributed. During September and October (figs. 59E and 59F) occurrences were observed over the entire study area in moderate to low abundance.

Rhodomonas minuta

Populations of Rhodomonas minuta, a small flagellate, has been reported from all of the Great Lakes (Munawar 1975). It reaches highest abundances in slightly enriched areas. Uniform distribution at moderate abundances were observed for April (fig. 60A). In May (fig. 60B) populations were observed over the entire study area with highest cell densities occurring in the Canadian sector of the southern basin. Reduced abundances were recorded for June (fig. 60C) with the highest abundances for the cruise being noted in the offshore waters, particularly in the central basin. Greatly reduced occurrences and abundances were observed in July (fig. 60D). The populations were centered in the offshore waters following the long axis of the lake. Wider occurrence at modest abundance was observed in September (fig. 60E) predominantly in the offsore waters. In October (fig. 60F) slightly elevated abundances and greater occurrences were observed in generally uniform distribution.

Rhodomonas minuta var. nannoplanctica

This variety of Rhodomonas, as the nominate variety, has been reported from all of the Great Lakes. Uniform distribution at moderate to low abundances were observed in April (fig. 61A). In May (fig. 61B) it was widely

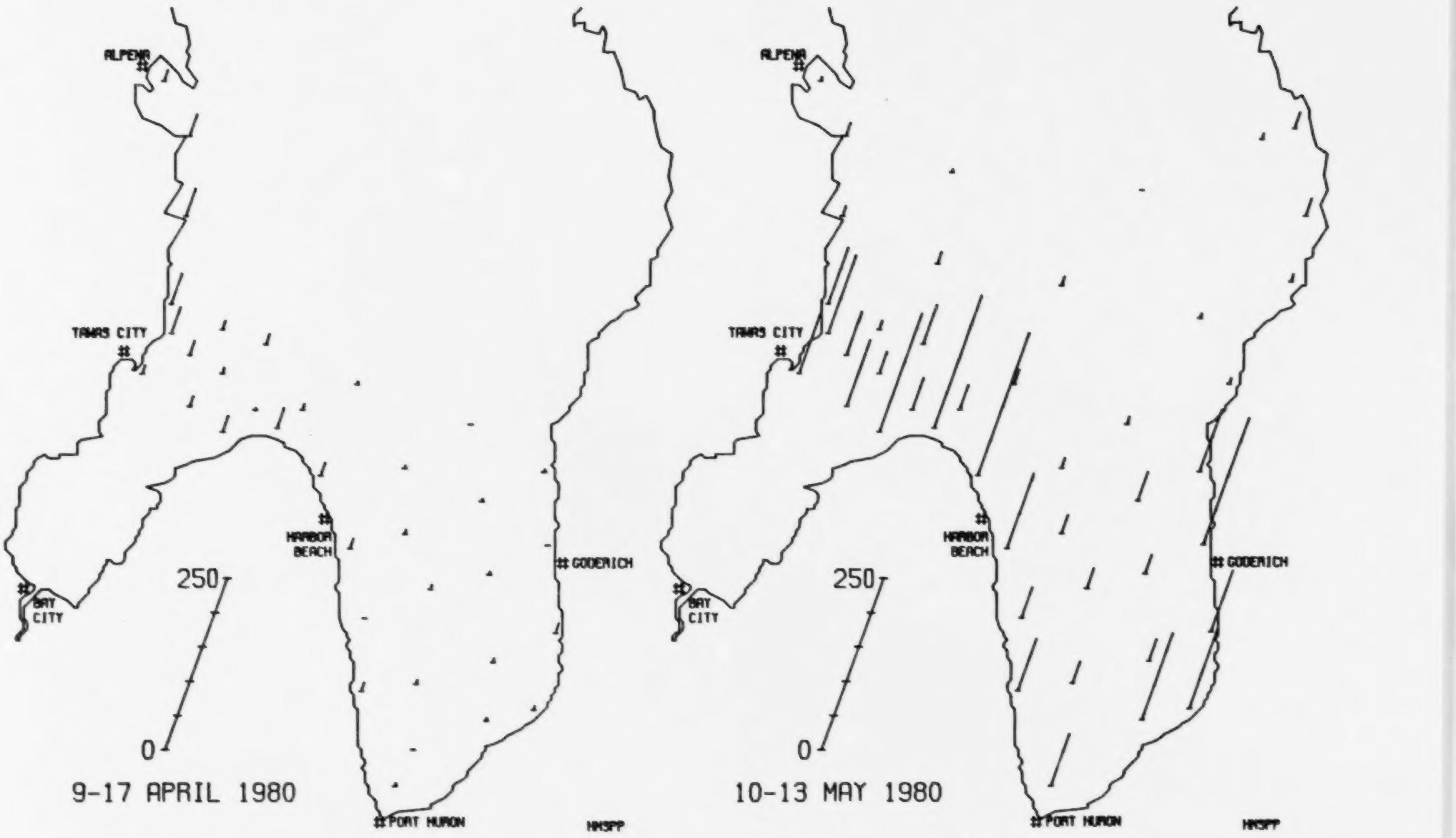
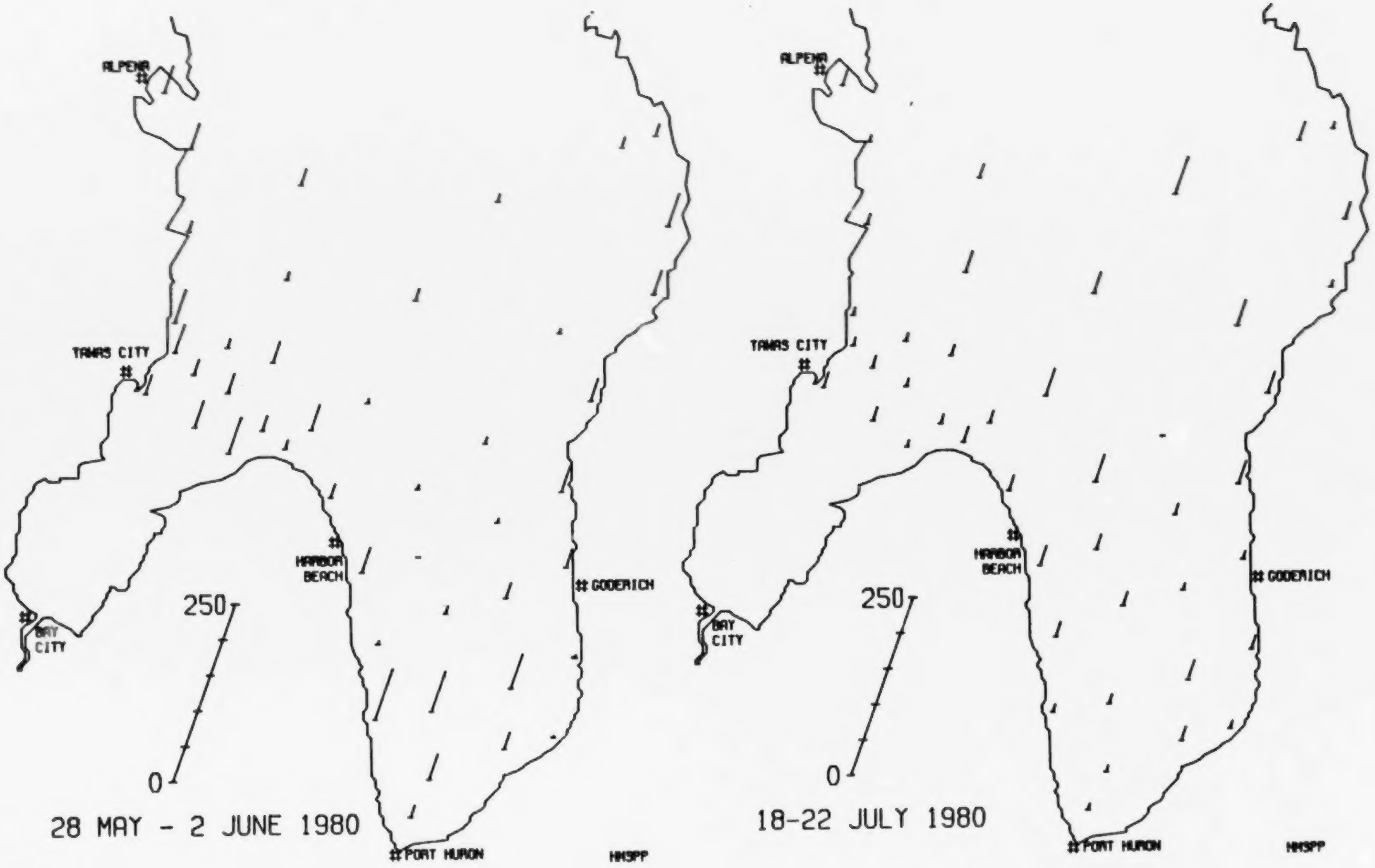

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
PORT HURON
GODERICH
HMSPP
250
0
9-17 APRIL 1980
10-13 MAY 1980

Figure 59. Distribution of Chroomonas spp.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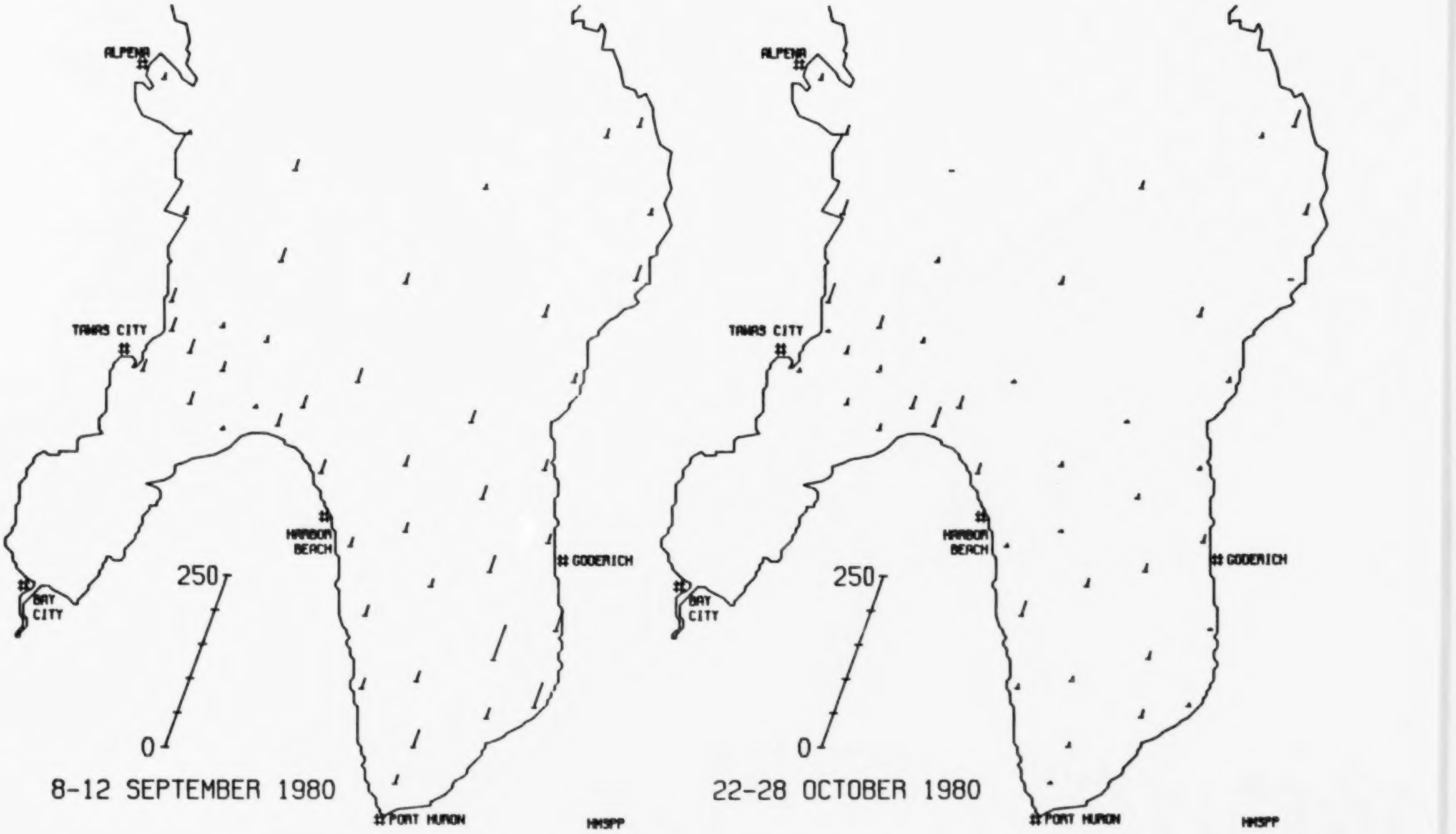
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
250
0
HMSPP
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
250
0
HMSPP

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 59. (continued)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BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
250
0
HMSPP
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
250
0
HMSPP

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 59. (continued)

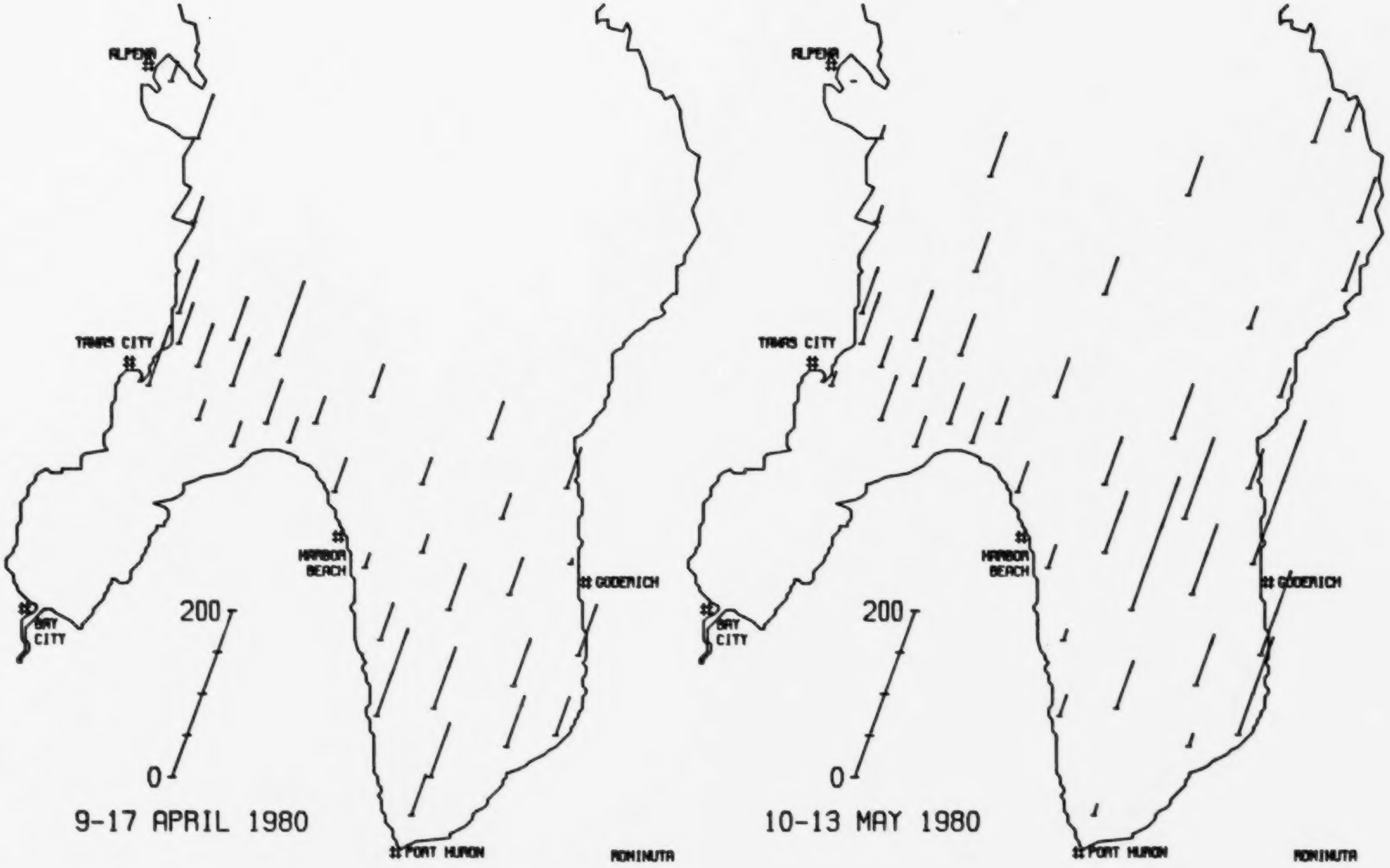

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
200
0
9-17 APRIL 1980
RMINUTA
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
200
0
10-13 MAY 1980
RMINUTA

Figure 60. Distribution of Rhodomonas minuta.

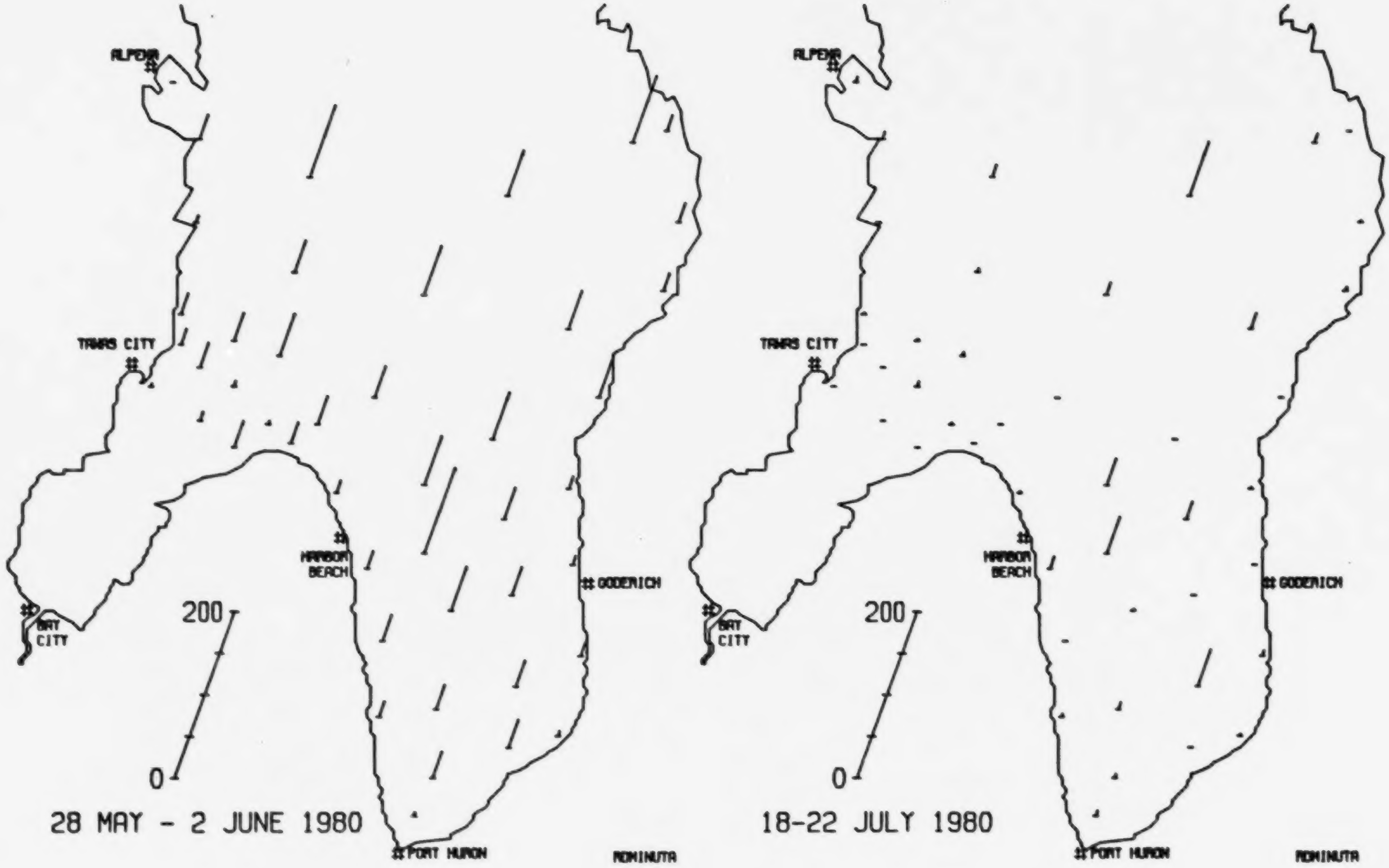
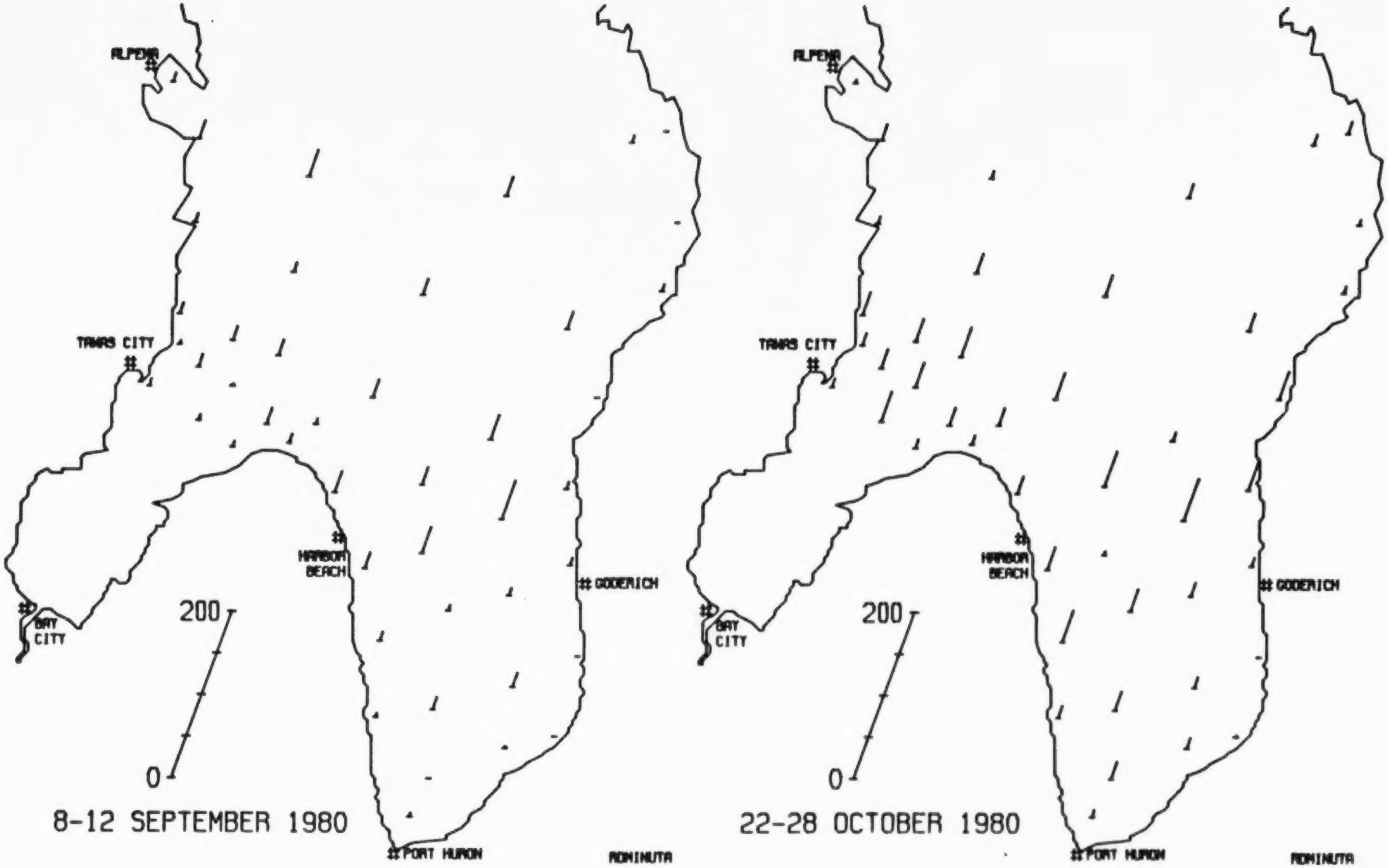

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
ROMINUTA
200
0
28 MAY - 2 JUNE 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
ROMINUTA
200
0
18-22 JULY 1980

Figure 60. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
ROMINUTA
200
0

8-12 SEPTEMBER 1980

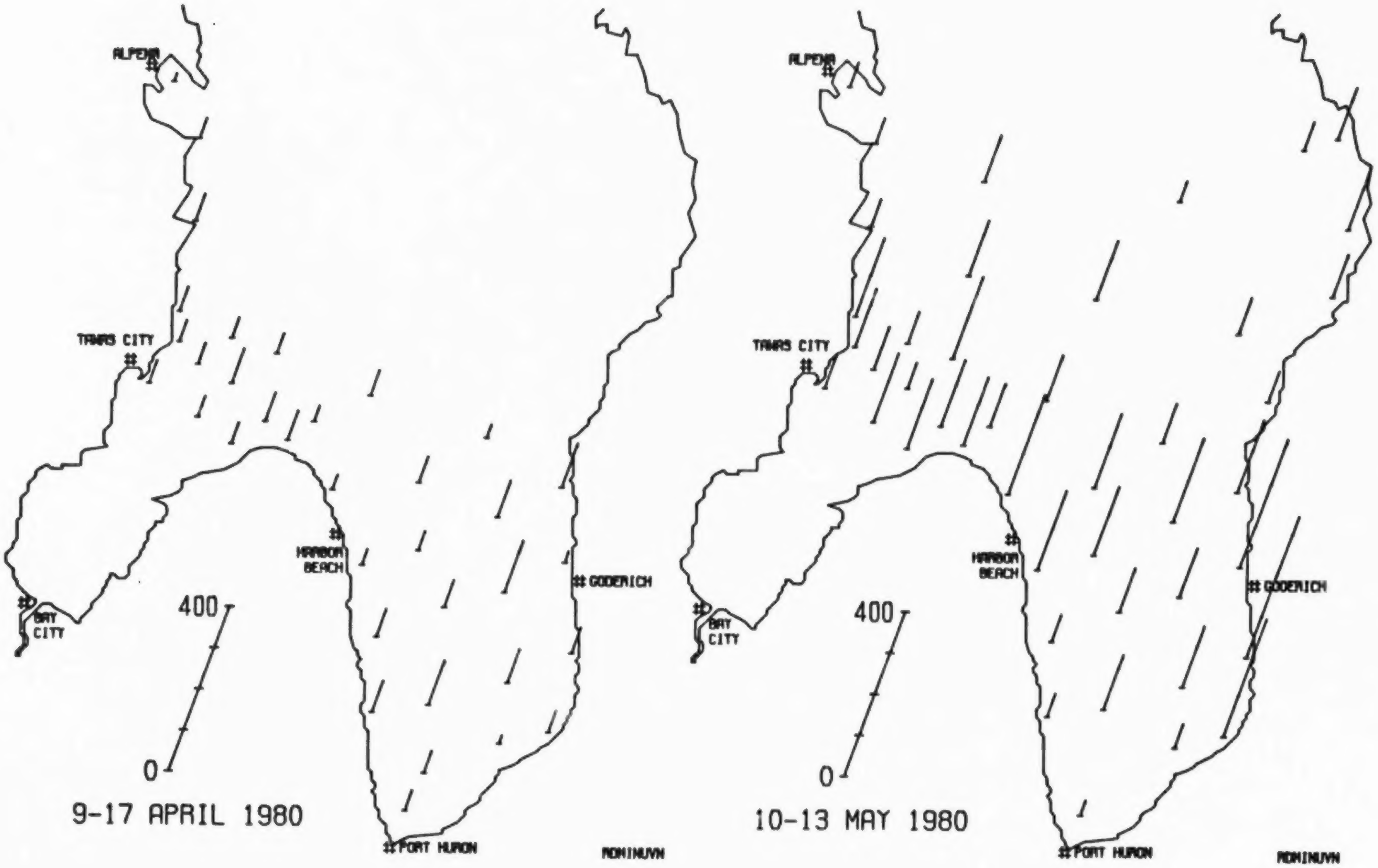
22-28 OCTOBER 1980

Figure 60. (continued)

distributed at greater cell numbers. Greatest abundances were found at nearshore localities near Goderich and the U.S. coastline. Generally a uniform distribution was seen in June (fig. 61C) however this taxon was substantially reduced near Goderich. During July (fig. 61D) highest abundances were seen in the offshore waters, particularly in the central basin. In September and October (figs. 61E and 61F) this form was widely distributed in moderate numbers but was centered primarily in the open lake.

PYRRHOPHYTA - DINOFLAGELLATES

The dinoflagellates usually comprise a relatively small fraction of phytoplankton assemblages in the upper Great Lakes. However, due to the large size of certain species, they may contribute a substantial portion of biomass to the assemblage. Dinoflagellates may typically form water blooms which are best known in the marine situation, especially concerning the red tide (Sweeney 1976). In the Great Lakes substantial populations have been observed in Lake Erie, particularly during the spring months (Munawar and Munawar 1976). In southern Lake Huron, dinoflagellates constituted only a minor portion of the algal assemblage . Dinoflagellates exhibited fairly low abundances in April (fig. 62A) but occurred throughout the study area. Highest abundances were seen in outer Saginaw Bay and nearshore, south of Goderich. Increased abundances were recorded in May (fig. 62B) particularly in the coastal areas south of Alpena, Saginaw Bay and Goderich. Largest abundances for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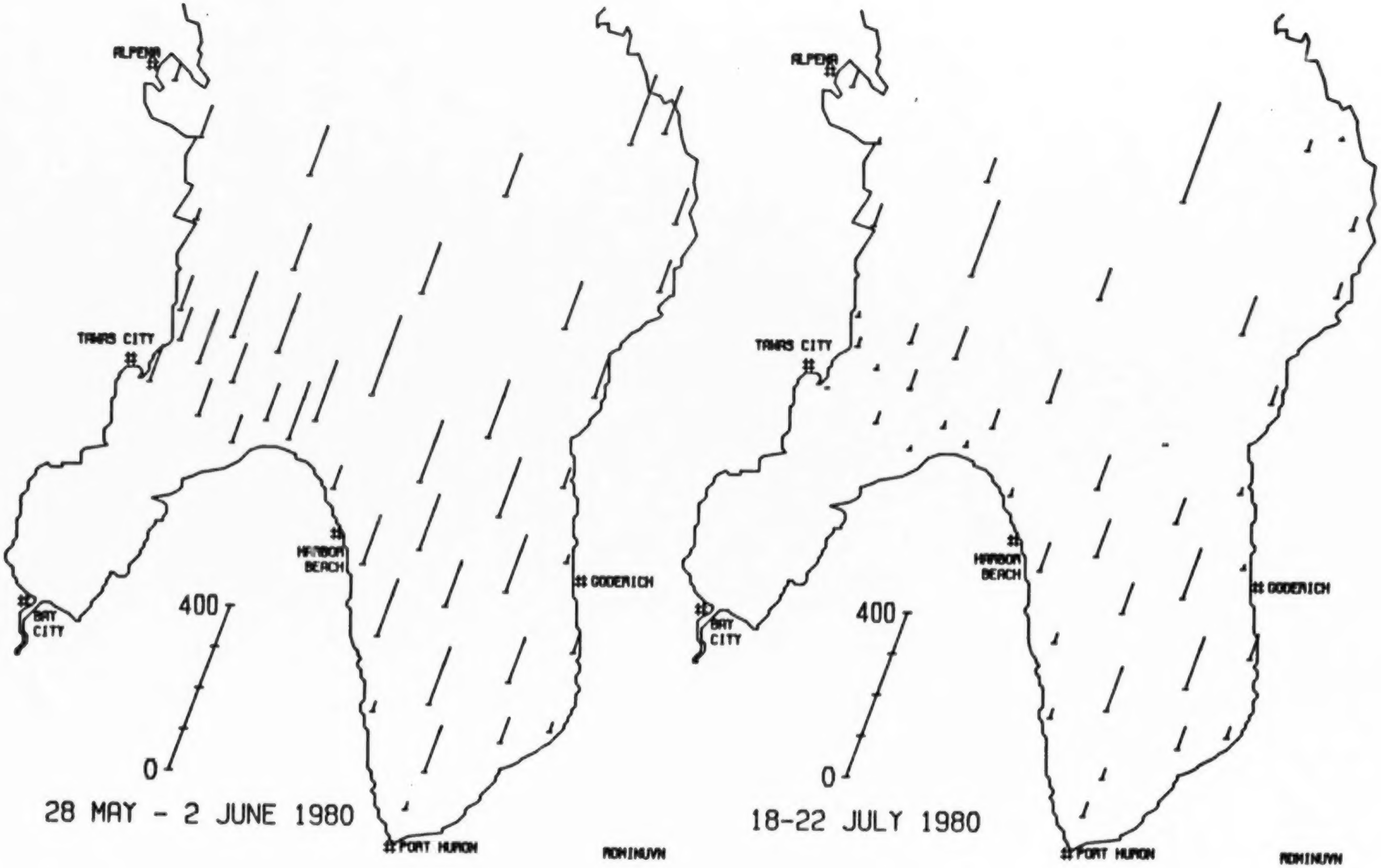
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
RDMINUVN
400
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
HARBOR BEACH
BAY CITY
GODERICH
PORT HURON
RDMINUVN
400
0
10-13 MAY 1980

Figure 61. Distribution of Rhodmonas minuta var. nannoplanctica.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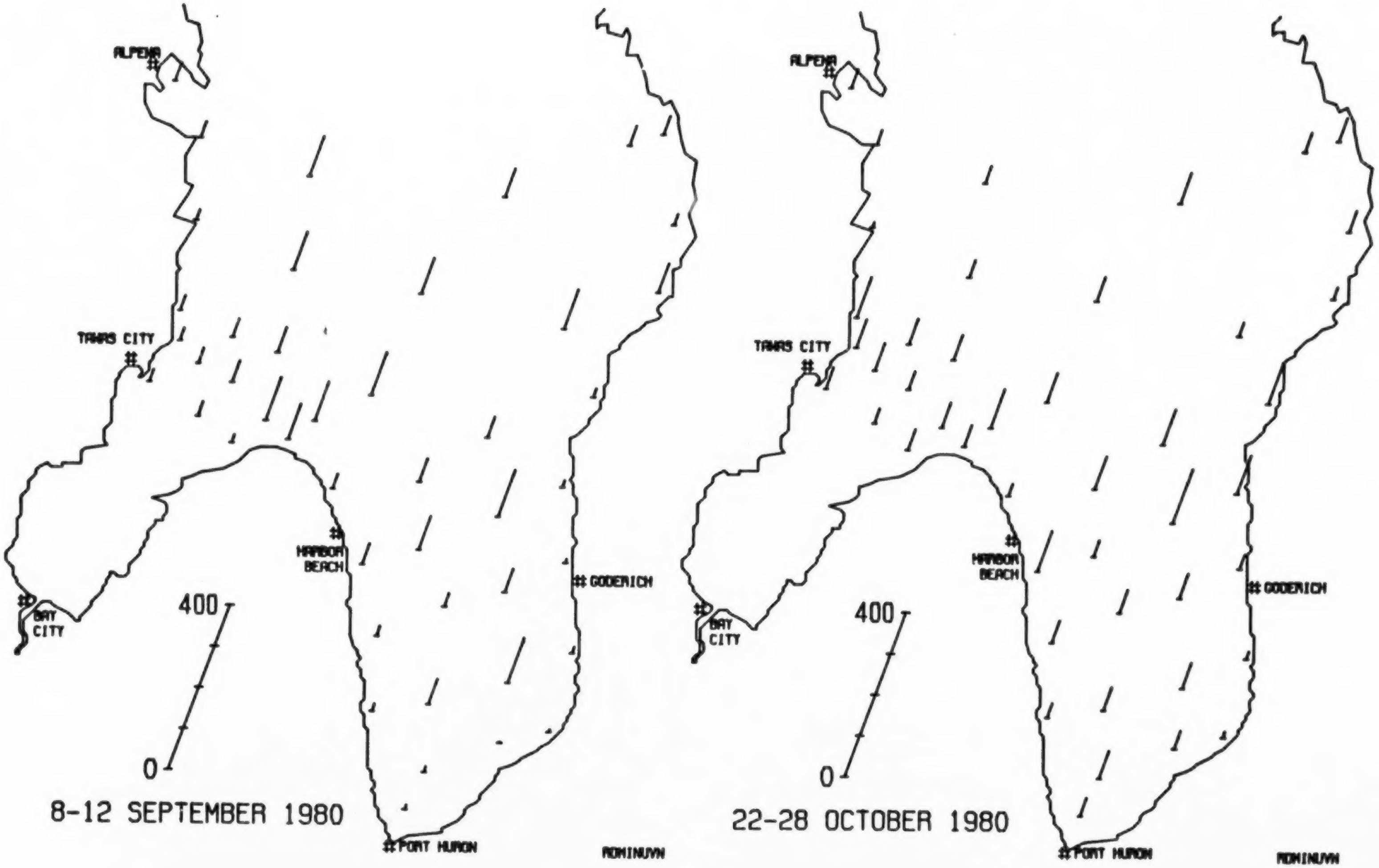
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
ROMINUVN
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
400
0
ROMINUVN

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 61. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
ROMINUVN
400
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
ROMINUVN
400
0

8-12 SEPTEMBER 1980

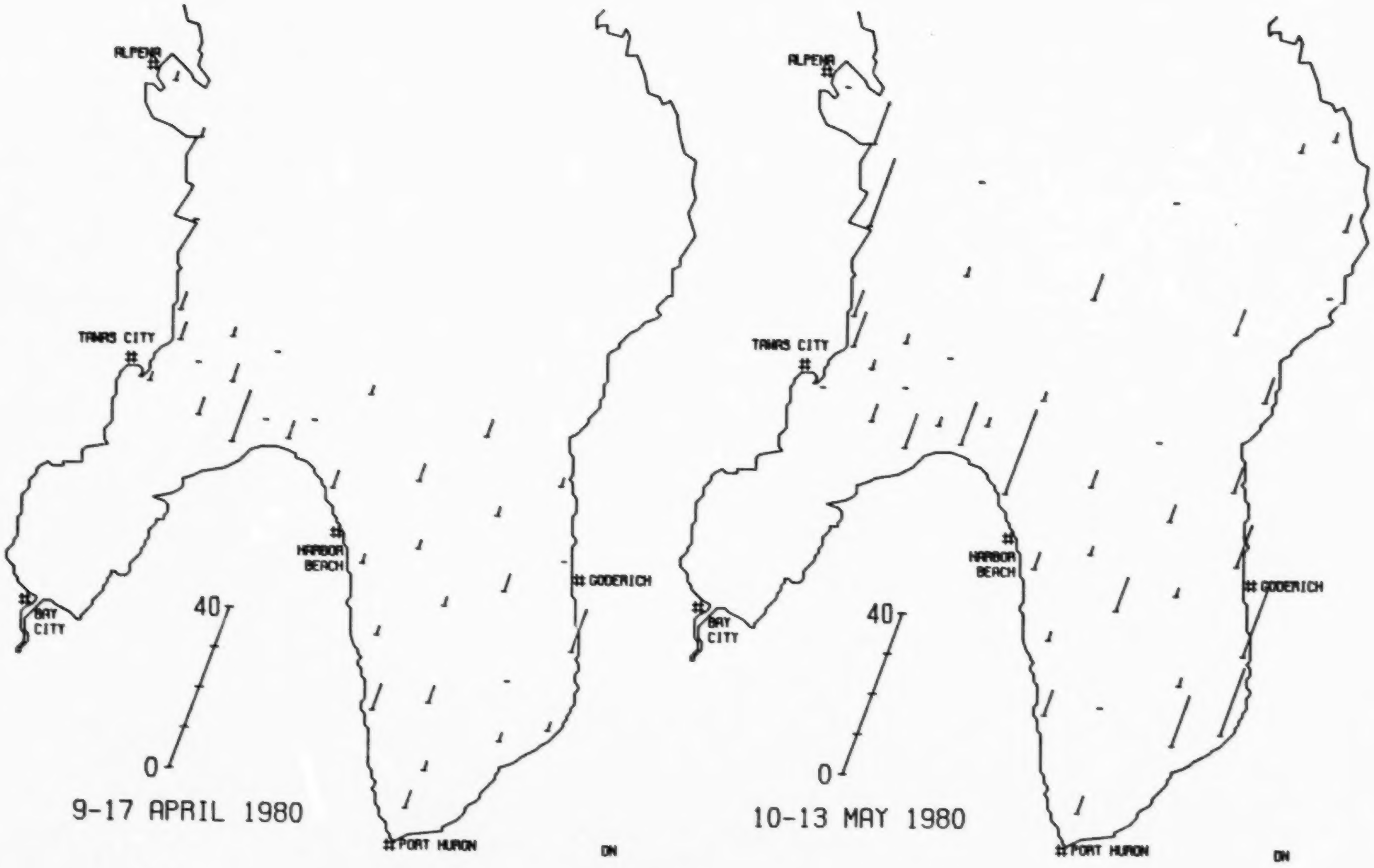
22-28 OCTOBER 1980

Figure 61. (continued)

the season were recorded in June (fig. 62C). Greatest abundance was seen at a single station in the mid-southern basin. High abundances were also seen at Alpena, in Saginaw Bay and the nearshore zone of the northeastern sector. Decreased cell numbers were observed in July (fig. 62D) with higher abundance being noted again at Alpena and in Saginaw Bay. Slightly higher values were recorded in September (fig. 62E) especially in the Saginaw Bay interface, however no distributional trends were apparent. Substantially reduced cell densities were observed in October (fig. 62F) and although widely distributed, exhibited no distinct pattern.

Gymnodinium oridinatum

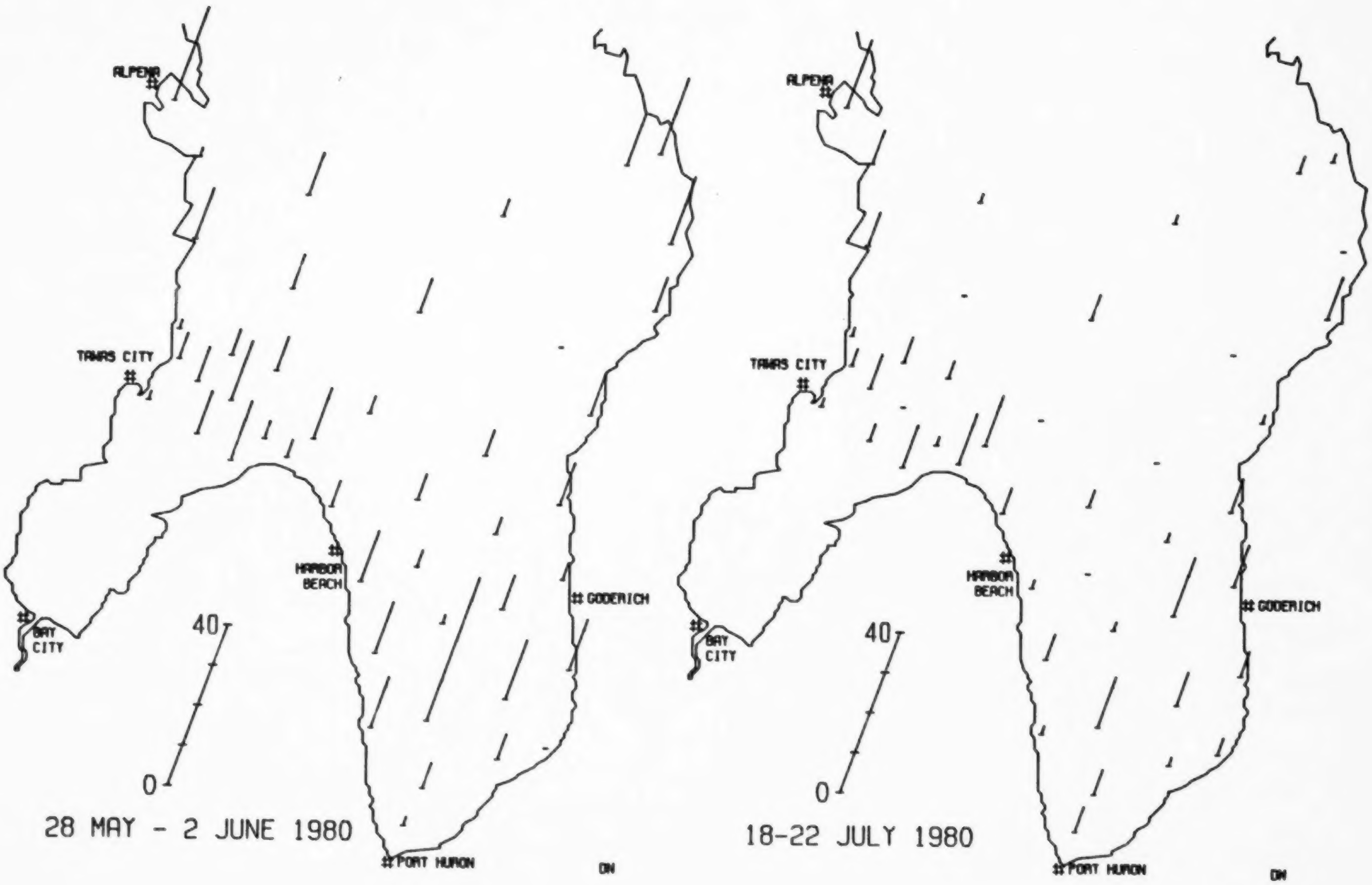
This species is a relatively small dinoflagellate whose ecology is unknown for the Great Lakes. It has previously been reported from Lake Huron (Nicholls et al. 1977) and Lake Superior (Munawar and Munawar 1978) in low abundance. In southern Lake Huron it was distinctly most abundant during the spring months. In April (fig. 63A) this species reached its widest occurrence and highest average abundance. It was present throughout most of the southern basin. Its greatest abundance was in the nearshore zones of outer Saginaw Bay, south of Goderich and between Harbor Beach and Port Huron. During May (fig. 63B) reduced occurrences and abundances were observed. Highest cell densities were located south of Saginaw Bay. In June (fig. 63C) occurrences were observed in the southern basin


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DN
40
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DN
40
0

9-17 APRIL 1980

10-13 MAY 1980

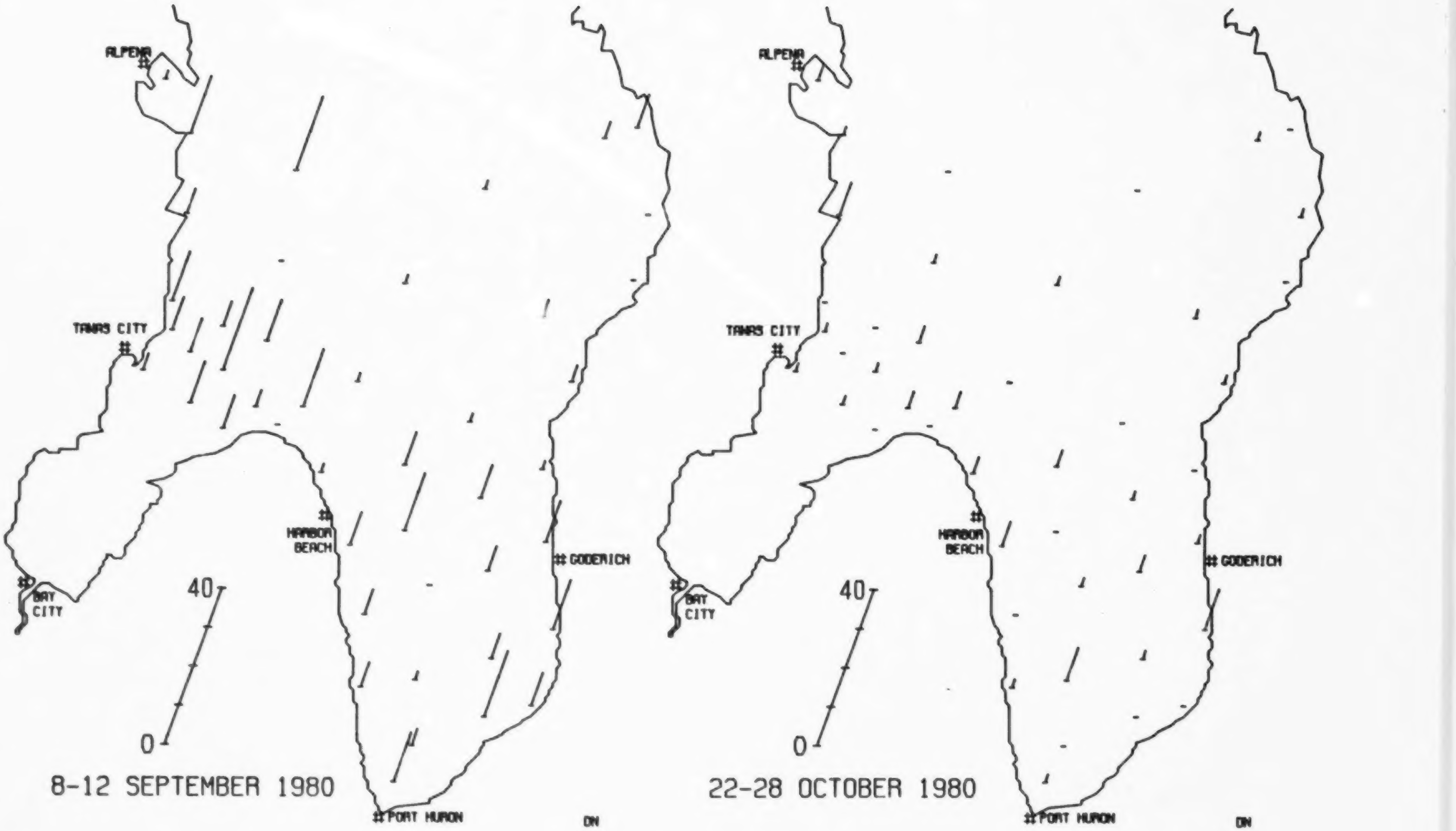
Figure 62. Seasonal distribution and abundance trends of Dinoflagellates.


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DN
40
0

28 MAY - 2 JUNE 1980

18-22 JULY 1980

Figure 62. (continued)


ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DN
40
0
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
DN
40
0

8-12 SEPTEMBER 1980

22-28 OCTOBER 1980

Figure 62. (continued)

and in the northeastern sector of the central basin. A large abundance was noted in the mid-southern basin. From July through October (figs. 63D - 63F) standing crops were greatly reduced with isolated occurrences predominantly in the southern basin.

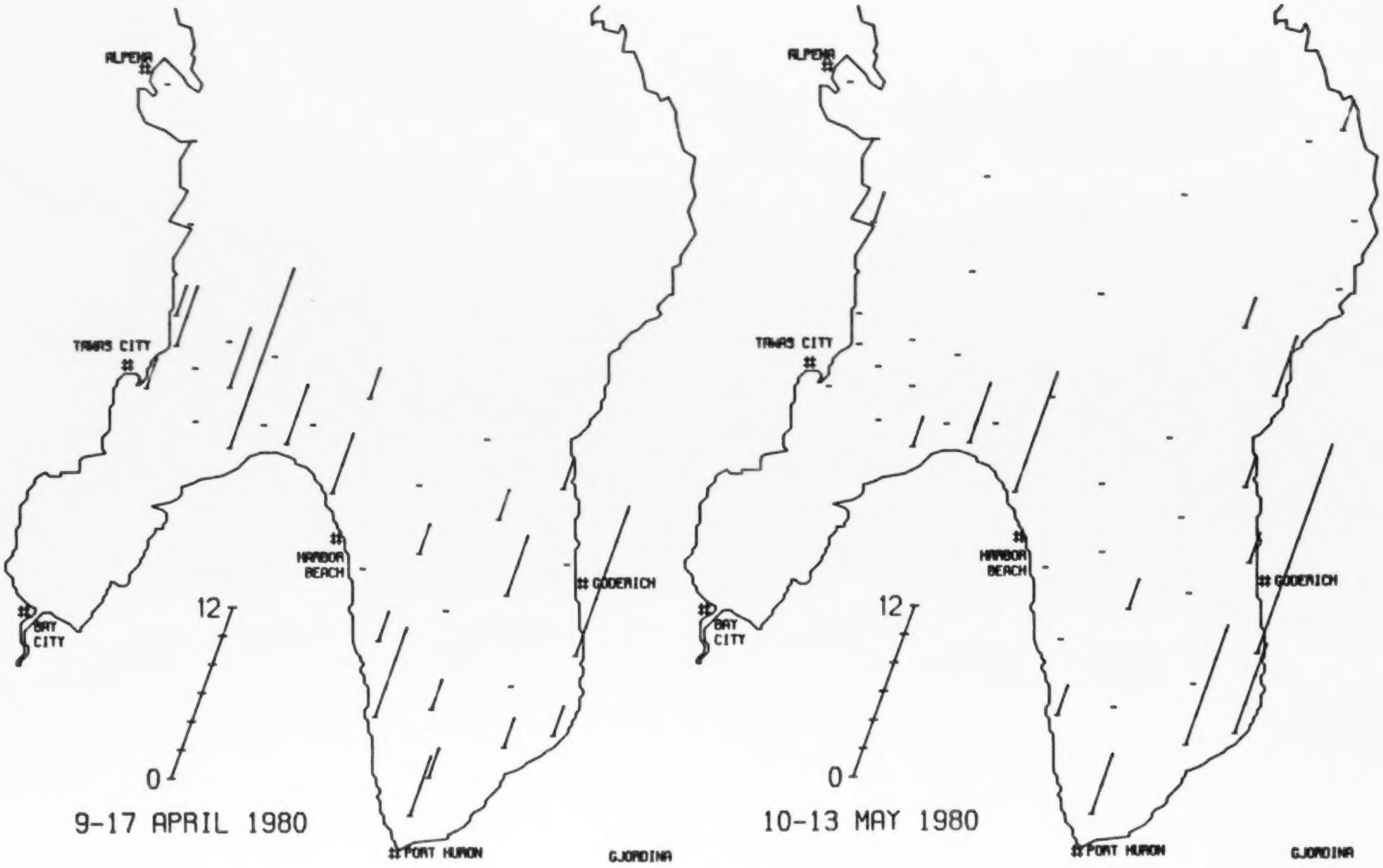

ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GJORDINA
12
0
9-17 APRIL 1980
ALPENA
TAWAS CITY
BAY CITY
HARBOR BEACH
GODERICH
PORT HURON
GJORDINA
12
0
10-13 MAY 1980

Figure 63. Distribution of Gymnodinium ordinatum.